SCIENCE ABSTRACTS.

Section A.—PHYSICS.

OCTOBER 1918.

GENERAL PHYSICS.

1010. *Harmonic Synthesiser.* **W. J. Raymond.** (Phys. Rev. 11. pp. 479–481, June, 1918. Abstract of paper read before the Am. Phys. Soc., March, 1918.)—A brief description is given of a harmonic synthesiser having components of incommensurable period and any desired decrement which is under construction in the Physics Department of the University of California. Three parallel shafts carry truncated cones of the same vertical angle, the larger end of one cone opposite the smaller end of the next. Friction wheels transmit the motion from cone to cone, and by setting a wheel at any desired place along the slope of the cones any required ratio of speeds may be obtained, commensurable or incommensurable. Each shaft carries also a shallow circular box, on the cover of which is a projecting eccentric pin which actuates a slotted cross-head of the usual type. If the pin is at a fixed distance from the centre of the box, and if the shaft turns uniformly, the motion of the cross-head is simple harmonic. But if the pin is made to move towards the centre while the shaft is turning, the motion of the cross-head is damped harmonic, the kind and amount of the damping depending on the rate at which the pin is moved towards the centre. The decrement of the motion may be logarithmic or rectilinear or of any other desired type. To secure the radial motion of the pin a cam is placed inside the box, the cam being actuated by an independent shaft passing centrally through the hollow shaft which carries the box. The pin is carried by a slide on the cover of the box and projects inwards through a slot in order to engage the cam. The curve of the cam and the relative angular velocity of the cam and the box will determine the rate at which the pin is drawn towards the centre of the box, and consequently the nature of the motion of the cross-head. By the use of a cord passing over pulleys attached to the cross-heads, the motions of two or more of them may be compounded and shown graphically by means of a pen attached to the cord. The instrument can be extended if necessary so as to have more than three components.

A. W.

1011. *Characteristics of the Marvin Pyrheliometer.* **P. D. Foote.** (Bureau of Standards, Bull. 14. pp. 605–634 [Sci. Papers No. 323], 1918.)—The receiver of the Marvin pyrheliometer consists of a blackened silver disc placed at the bottom of a tube which faces the sun. In taking a reading the solar rays are alternately allowed to fall upon the disc and excluded by the closing of a shutter, the rate of heating and cooling of the disc being measured by an electrical resistance thermometer. The alternate periods of heating and cooling are normally 60 secs. The instrument is generally calibrated by passing a current of known strength through a coil enclosed in the silver disc and determining the rise of temperature produced by this known heat source in a definite time interval. In the present work calibration was also effected by exposing the pyrheliometer to radiation from a black body raised to a high temperature. The difference between the results from the two methods of calibration amounted to about 3 %. The theory of the instrument is gone into in detail and the errors arising in both methods of calibration are discussed. The radiation method employed suffered from the serious defect that the max. heat energy which could be transmitted to the pyrheliometer per unit time was only 1/30th that of the solar radiation. It is believed that the calibration error may amount to 5 %. An important conclusion reached is that the lag effect is eliminated if the temperature readings are taken 10 secs. and 60 secs. after commencing an exposure instead of 0 secs. and 60 secs. No advantage is gained by increasing the time of exposure to 120 secs. J. S. Di.

1012. *Variability of Glass Hydrometer Floats.* **W. Block.** (Zeits. Instrumentenk. 38. pp. 40–44, March; 54–59, April; 75–80, May; 89–94, June, and pp. 115–120, July, 1918.)—A series of five articles describing tests on the best German commercial hydrometers. The accurate temperature and the thermal expansion of the floats are carefully measured. The errors arising at various temperatures are observed in a great variety of cases, but the results are voluminous and are not summarised. P. E. S.

1013. *Time-measurement to the Thousandth of a Second.* **R. A. Sampson.** (Roy. Astron. Soc., M.N. 78. pp. 592–614, June, 1918.)—The microchronograph here elaborately described is a device for avoiding the mechanical lag generally found in a signal train, the signal given directly or indirectly by the pendulum being sent through an Einthoven galvanometer, whose wire loop controls a mirror, and can thus have its movements registered by photography. To avoid dependence on variable conditions an interrupter with a period of nearly one-tenth of a second is employed to give a sort of vernier scale, and advantage is taken of the very powerful electromagnet built at Edinburgh Observatory by Crawford in 1870 to provide a sufficient current external to the signal circuit to give measurable deflections. The results of trials with three different clocks are given, one of which gives signals directly from the pendulum. The small irregularities of these and of the ordinary Fuess chronograph are discussed in great detail, with the effect of altering the conditions of the signal, the relay, etc., and tables are included of the deviations from uniformity indicating that in the mean the error is less than 0·001 sec. W. W. B.

1014. *Determination of End Standards of Length.* **C. E. Guillaume.** (Rev. Gén. d'Él. 4. pp. 171–178, Aug. 10, 1918.)—An historic account, brought up to date, of methods of comparing end standards and line standards. The old practice was to observe by microscope the point of contact of a point and its image reflected in the polished, square end of the end standard.

Later Benoît and Guillaume improved this method by having a fine thread stretched horizontally on the squared faces of the ends.

Still later, about the beginning of the century, a method was used at Sévres in which specially prepared sphere-ended agate contacts were brought by known constant pressure against the ends of the standards. On comparing the last (contact) method with the optical methods described before, the surprising discrepancy of 4 μ was discovered between the two methods. The cause was discovered to be lens aberration, and as a result the method of viewing an object on the end face of a standard was henceforth discredited; and some form of contact method ever after employed. Two modern methods are described, the first a direct outcome of the old contact method already described, the second being due to Airy. In this last method three sphere-ended gauges are used, each with an index line. By arranging these, two at a time, in every possible combination, twelve in all, great exactness is secured in the measurement of the length of each gauge. Details of this method are given. It is to be understood that in all the methods described the comparator is the instrument used for measuring the distance between contact points, or lines of reference, or lines on a line standard.

The advantages, or otherwise, of sphere-ended or plane-ended standards are considered.

This brief but comprehensive account contains 13 illustrations. P. E. S.

1015. *The Definition of Hardness.* **R. M. Leslie.** (Engineering, 106. p. 153, Aug. 9, 1918.)—Describes experiments carried out in order to measure the work required to produce a unit volume, viz. 1 mm.^{3}, of indentation. A weight of ½ kg. was dropped half a metre in each case; but the shape of the tool dropped was varied, and the results indicate that the indentation volumes obtained agree closely. With a hatchet tool the following scale was obtained :—

	Displacement Volume. mm.^{3}	Hardness.		Displacement Volume. mm.^{3}	Hardness.
Carbon tool-steel, hardened	0·0623	401	Mild steel........................	0·64	39
Carbon tool-steel, tempered straw	0·09	278	Brass	1·11	23
Carbon tool-steel, tempered blue	0·19	131	Copper	1·3	19
Carbon tool, from bar, normal ...	0·212	118	Lead................................	13·0	2
Carbon tool, annealed	0·387	65			

It is suggested that if hardness be defined as resistance to deformation, then as work only can mechanically produce deformation, work should be used as a measure of hardness. C. O. B.

1016. *Rupture of Liquids between a Rolling Sphere and a Plane Plate.* **M. Toepler.** (Ann. d. Physik, 55. 5. pp. 337-370, June 4, 1918.)—If a sphere with a radius of curvature between 10 and 100 cm. is rolled on a flat plate, and if a liquid is present between the ball and the plate, the liquid is ruptured behind the point of contact as the speed of rolling is increased. In the author's experiments an oscillating spherical lens was employed in place of a progressively moving ball, and it was found that if a premature or delayed rupture of the liquid is avoided, the breaking of the liquid takes place very regularly at a particular velocity of rolling (V_R) which, for different liquids, is given by the approximate equation $V_R . \eta = 0{\cdot}00714$, where η is the coefficient of viscosity of the liquid in dynes-sec./cm.^{2}, and V_R is measured in cm./sec. The rupture of the liquid takes place at the points where the thickness of the layer has a definite value, nearly the same for different liquids, namely $5{\cdot}44 \times 10^{-6}$ cm. The reason for the rupturing of the liquid is doubtless due to an overstepping of a definite value of rotary flow (*Strömungsrotor*) within the liquid which is given by $P_R . \eta = 7860$ gm./cm. sec.². At the moment of rupture, the internal liquid pressure at the point of rupture is $1\text{–}1{\cdot}125\rho^{1/2}$ atmo., where ρ is the radius of curvature of the rolling lens.

A. F.

1017. *Thickness of Wall for Tubes under Pressure.* **M. Suwalski.** (Zeits. Vereines Deutsch. Ing. 62. pp. 551–552, Aug. 17, 1918.)—Gives formulæ for the thickness of tube required to withstand given pressures, using the simple formula $pd = 2sk_z$, where p is the pressure in kg./cm.² d is the inner diam., s the thickness of the tube, and k_z the tensile strength in kg./cm.². This simple equation is modified by putting $k = A(1 + d/200)$, A being a constant depending on the value of p. J. W. T. W.

1018. *Tests of Large Bridge Columns.* **J. H. Griffith** and **J. G. Bragg.** (Bureau of Standards, Technol. Papers, No. 101. [139 pp.] Washington, 1918.)—Gives the results of an investigation of 18 test members; the tests being for the purpose determining the strengths of the columns under intended axial loads and to obtain data for studying the distribution of stresses in the columns. The results are summarised in 14 paragraphs which are too lengthy for reproduction. L. H. W.

1019. *Energy of the Gravitation Field in Einstein's Theory.* **G. Nordström.** (K. Akad. Amsterdam, Proc. 20. 9. and 10. pp. 1238–1245, 1918.)—In a preceding paper the author considered some general theorems derived from Einstein's gravitation theory, and especially a field with spherical symmetry [Abs. 822 (1918)]. Referring to this paper, the energy of the gravitation field is now calculated according to Einstein's conception. In order to obtain a result that also holds for an electric field, the author first calculates the gravitation field of an electric centre [see Abs. 998 (1917)], and then proceeds to evaluate the distribution of the energy in a gravitation field with spherical symmetry. H. H. Ho.

1020. *On a Relationship between the Gravitation Constant and the Fundamental Quantities of Electrical Theory.* **A. Haas.** (Phys. Zeits. 19. p. 330. Aug. 1, 1918.)—The author here discusses two of the universal physical constants which are of special importance in electrical theory, namely: $Z_1 = e/mK^{1/2}$, and $Z_2 = M/m$; here e and m represent the charge and mass of a negative electron, K is the gravitation constant, while M is the mass of the hydrogen atom nucleus. He then shows that a simple relationship exists between Z_1 and Z_2 in the form of the equation $Z_1 = \pi^{\sqrt{Z_2}}$. H. H. Ho.

1021. *Some Two-dimensional Potential Problems connected with the Circular Arc.* **W. G. Bickley.** (Phil. Mag. 35. pp. 396–404, May, and 36. 273–279, Sept., 1918.)—In the first article the author gives the solution of some potential problems connected with the circular arc, and interprets the results in terms of electricity and hydrodynamics. In the second article he gives drawings of the stream lines in the case of the disturbance of a stream due to a long lamina in the form of a circular arc; and the motion of the arc when free to move is discussed. L. H. W.

1022. *Formulæ for Trajectories of Anti-Aircraft Shells.* **G. Manetti.** (Rivista Maritima, 50. pp. 29–38, Oct., 1917. Am. Soc. Mech. Eng., J.

40. pp. 350–352, April, 1918. Abstract.)—The formulæ used are expressed in the notation used in the works on ballistics by Siacci and by Ronca in Italy, and are too lengthy for reproduction here. L. H. W.

1023. *Production and Measurement of High Vacua.* **J. E. Shrader** and **R. G. Sherwood.** (Phys. Rev. 12. pp. 70–80, July, 1918.)—The full paper corresponding to Abs. 444 (1918).

1024. *The Gyro-stabiliser for Ships.* **N. Watanabe.** (Math. Phys. Soc., Tōkyō, Proc. 9. pp. 369–387, June, 1918.)—An elaborate mathematical treatment reviewing the work of O. Schlick and of E. A. Sperry and working out a number of detailed cases. [See Abs. 1198B (1904) and 466B (1911).] E. H. B.

1025. *On the Motion of a Light Spherical Ball in Air.* **P. Appell.** (J. de Physique, 7. pp. 49–52, March–April, 1917.)—In a previous communication [Abs. 328 (1917)] the author proposed a simplified hypothesis for the explanation of Carrière's experimental results. In these experiments the ball turned about an axis normal to the plane of the trajectory. The case for any given instantaneous axis of rotation is now investigated. The resistance $R = mg\phi(V)$ at the place where opposed to the speed of the centre G, is obtained by rotating the vector $mg\phi(V)$ contrary to the velocity of G through an acute angle α around the instantaneous axis of rotation $G\omega$ of the ball, and in a reverse direction to the rotation ; this angle α is an increasing function of the magnitude ω of the instantaneous rotation and vanishes with ω. If the instantaneous axis of rotation is a tangent to the trajectory the resistance is opposed to the speed when the rotation is nil. Rayleigh's work : "On the irregular flight of a tennis ball," is discussed at some length, following which comes a reference to Greenhill's results on the motion of a light celluloid ball. The author now completes his former investigation by deriving the equations of motion for the ball. H. H. Ho.

1026. *Mechanical Theories of the Electromagnetic Field.* IX. **A. Korn.** (Phys. Zeits. 19. pp. 327–330, Aug. 1, 1918.)—This paper deals with the fundamental principles of the mechanical theory of friction. The change effect (*Wechselwirkung*) between two impacting particles is first considered [see also Abs. 911, 912 1918)], and the author shows that Maxwell's repulsion law (the repulsion of two particles is inversely proportional to the fifth power of their distance) may be derived from the theory of universal oscillations. He proves that if a rigid particle moves with a velocity V in a direction s in a medium under friction effects, then the medium will exert a retarding force on the particle proportional to the absolute velocity. While the latter result is not original, the author claims the credit of having obtained it by purely mechanical methods. H. H. Ho.

1027. *Crystal Structure of Ice.* **A. St. John.** (Nat. Acad. Sci., Proc. 4. pp. 193–197, July, 1918.)—An account of a careful X-ray analysis of the structure of ice. Special precautions were taken to keep the ice in a perfectly dry condition and to prevent sublimation. When protected in the manner described specimens of ice crystals were preserved for days. Commercial artificial ice was first examined as it shows a marked prismatic structure. Unfortunately the prisms are distorted through pressure in the formation of the ice, so that it is difficult to identify cleavage planes. Measurements on carefully prepared ice crystals, however, show that ice is properly assigned to the hexagonal system; that it contains four interpenetrating triangular lattices, and that the fundamental spacings are: $a = 4{\cdot}74 \times 10^{-8}$ cm.; $h = 6{\cdot}65 \times 10^{-8}$ cm.; $d_{1120} = 3{\cdot}79 \times 10^{-8}$ cm.; $d_{1010} = 2{\cdot}37 \times 10^{-8}$ cm.; $d_{0001} = 3{\cdot}32 \times 10^{-8}$ cm. A. B. W.

1028. *The Atmospheric Circulation above Australasia according to Pilot Balloon Observations at Batavia.* **W. van Bemmelen.** (K. Akad. Amsterdam, Proc. 20. 9. and 10. pp. 1313–1327, 1918.)—The paper gives a general discussion of the winds above Batavia up to great heights. These are set out in an isopleth diagram showing the direction and velocity of the main air currents for each month at each level up to 24 km. In the southern summer the following distribution is found. A "West Monsoon" wind exists from the surface up to 6 km. This backs and turns into an easterly trade with a component from the south which extends from 7 to 12 km. Further backing brings in an "Anti-trade," *i.e.* an east wind with a component from the north which persists from 13 to 18 km. Above this a component from the south reasserts itself in the "Upper Trade Wind." At still greater heights there is evidence of the Krakatoa Wind, or strong east wind blowing at about 40 m./sec. In winter the above currents are found at lower levels, the surface west monsoon being squeezed out and the lower trade wind extending from sea-level to 4 km. height. In the middle of the upper trade a westerly wind is found at this season between 17 and 24 km. height.

The latter part of the paper discusses the probable pressure distribution at different levels associated with each of these currents and the more general wind system over a larger region of which they form a part. J. S. Di.

1029. *Scarf Clouds.* **C. F. Brooks.** (Monthly Weather Rev. 45. pp. 361–363, July, 1917.)—This name has been applied by Humphreys to a cloud which forms immediately over a rapidly rising cumulus dome and through which the latter passes without hesitation. These clouds generally have a brief existence, their life being only two or three minutes. The late afternoon seems most favourable to their formation. Numerous sketches are given of the clouds as observed on two occasions. The top of the cumulus did not move forward so fast as the flat clouds at the same level, and the suggestion is made that the scarf clouds may be due to the winds rising to pass over the dome of the cumulus rather than to the direct forcing up of the air stratum by the rising column below. J. S. Di.

1030. *Mean Annual Rainfall of the United States with Notes on the New Chart of Average Annual Precipitation from the "Atlas of American Agriculture" (Advance Sheet).* **R. DeC. Ward.** (Monthly Weather Rev. 45. pp. 338–345, July, 1917.)—In many parts of the United States rainfall records are scanty, and in preparing maps there have been two divergent schools of thought, one which took little account of the topography, being guided only by the available records; and the other which placed great weight upon the topographical features of the country and was largely influenced by these in drawing the isohyetal lines. The new annual rainfall map which has recently been published represents a compromise between these two extreme views. The size of the map is 24 by 16 in. and the isohyetal lines are drawn for every 5 in. of rainfall. A small inset map shows the percentage of the annual fall which occurs in the summer half-year. The present writer, in discussing the features of the map, divides the area into four main provinces. First the Eastern, which occupies the eastern half of the country and is bounded on the west by the 20-in. isohyetal. This runs approximately N. and S. along the 100° meridian. About half the area receives more than 40 in. per annum. The chief source of supply of moisture seems to be the Gulf of Mexico and, owing to the absence of any mountain chain, the water is carried far northward over the continent. The isohyetals run mainly NE. and SW., the rainfall decreasing to the N. and W. The Great Lakes in the north of this province seem to have little effect on the rain of the surrounding areas.

The next rainfall province westward covers the Great Plains, over which rainfall is generally below 20 in. and in some parts amounts to no more than 10 in. In this district farming is carried on with difficulty.

Further west again the plateau province is reached, which includes in the north the Rocky Mountains. Rainfall in the most mountainous northern parts of this province reaches 40 in.; in the south it is mostly below 10 in. Here is the desert region surrounding Great Salt Lake. The influence of the Rockies is not so important as might at first be expected. The important ranges of the Sierra Nevadas and Cascades nearer the Pacific coast have already robbed the air of much of its moisture.

The last province consists of a narrow belt along the Pacific coast. In the northern part of this the heaviest falls of the country are found, greater than 120 in. To the south the falls decrease, this effect being opposite to that found on the Atlantic seaboard. The paper concludes with a bibliography. J. S. Di.

1031. *Nocturnal Radiation Measurements.* **H. H. Kimball.** (Monthly Weather Rev. 46. pp. 57–70, Feb., 1918.)—Radiation was measured by means of a modified form of Ångström's pyrgeometer. In this instrument the loss of heat from two blackened strips exposed to the sky is determined by measuring the electric current which must be passed through them to maintain their temperature equal to that of two bright non-radiating strips similarly exposed. The rate of heat loss per cm.^{2} (R) from the blackened surface is thus determined. If i is the heating current through the blackened strips $R = Ki^2$, where K is the constant of the instrument. If further T_1 is the temperature of the strips and T_2 the effective black-body temperature of the sky to which radiation takes place, then $R = \sigma(T_1^4 - T_2^4)$, where σ is the radiation constant for a black body, assumed equal to $8{\cdot}18 \times 10^{-11}$ gm. cals. per cm.^{2} per min. in the present work. This value is 6½ % greater than that employed by Ångström. A method of determining the instrumental constant K by exposing the strips towards a black surface of known temperature is described and the resulting values for the three instruments used in the present work are set out. Allowance is made for the fact that the blackened strips are not perfect radiators nor the bright strips perfect reflectors.

Series of measurements were made at Mount Weather, Va., and Washington, D.C., from which it appears that the net outward radiation R ranges up to about 0·2 gm. cal. per cm.^{2} per min. at both these stations; being greater in the spring than in the autumn. If R is determined from the equation $R = Ki^2$ and if T_1 is also measured, the equation $R = \sigma(T_1^4 - T_2^4)$ allows the value of T_2 to be deduced and the incoming radiation can be determined as well as the outgoing. A diagram shows the net rate of heat loss, and also the atmospheric radiation to the earth, plotted against surface vapour pressure for clear nights. The heat loss falls from 0·23 gm. cal. per cm.^{2} per min. with v.p. 2·0 mm., to 0·11 with v.p. 16 mm. This decrease of net heat loss is brought about by an increase of incoming radiation with high vapour pressures. The effect of clouds on heat loss by radiation is discussed. High clouds have little effect, medium and low clouds reduce it markedly. It is found that in the winter the outgoing radiation from the ground is sufficient to balance the heat absorbed during the day from the sun, but in the summer this is not the case and a balance of at least one-half remains which must be accounted for by convection, evaporation, or other cause. J. S. Di.

1032. *Some Field Experiments on Evaporation from Snow Surfaces.* **F. S. Baker.** (Monthly Weather Rev. 45. pp. 363–366, July, 1917.)—In some districts of the Western United States irrigation is chiefly dependent upon the snow covering of mountains for its source of water supply. The loss of snow by evaporation is in these districts a matter of economic importance. Measurements were made twice daily of the loss by weight of a glass jar filled with snow and buried flush, the day and night evaporation being thus determined. The experiments could not be carried out on windy days when the snow was drifting or during periods of snowfall, but they fully cover the calm clear days of winter. The total loss during the winter 1915–16 was found to be equivalent to 3 in. of water or 14% of the total snowfall. A graph exhibits the relation between evaporation and temperature, showing a rapid rise at the higher temperatures. Even after allowing for temperature difference evaporation was more active by day than by night, though the wind velocity was the same at both times. Rolf has deduced a formula connecting evaporation with vapour pressure and temperature of the snow surface from observations in Lapland, but the present inquiry gives values two to three times greater than those deduced by this formula. Having determined by survey the amount of water lying in the form of snow on a given watershed and measured the run off by weirs the present determination of the loss by evaporation will enable an estimate to be made of the loss by percolation, the other important source of loss. J. S. Di.

1033. *Predicting Minimum Temperatures.* **J. W. Smith.** (Monthly Weather Rev. 45. pp. 402–407, Aug., 1917.)—In connection with agricultural work the prediction of night frosts is of great importance. Three methods of predicting the night minimum temperature from readings made the previous day and evening are dealt with, occasions of calm clear weather only being considered. (1) By making use of the normal diurnal range on such days at the particular station and subtracting this from the maximum of the previous afternoon an estimate of the coming night minimum can be obtained. (2) The second method consists in ascertaining at what hour in the evening the temperature reaches its mid-value between the previous maximum and the following minimum. The time of this median value fluctuates remarkably little from one day to the next under the calm clear conditions postulated, and having once been ascertained for each month of the year useful forecasts can be made by this means. (3) The use of an empirical equation connecting the night minimum with the dew-point and relative humidity in the late afternoon provides a third method which is fully discussed in the present paper. It has been found that the amount of the departure of the night minimum from the dew-point of the preceding evening is closely dependent upon the relative humidity at the time of the evening observation, the correlation between the two being as high as 0·87 at one station and having a mean value of 0·55 for 16 stations tested.

The variation is in the sense that high humidity is associated with great departure below the dew-point and low humidity with slight departure below, or even minimum readings above, the dew-point of the previous evening. An equation connecting the two quantities is worked out by the method of least squares. Forecasts of the night minimum which had a maximum error of 5° F were obtained by the use of this equation. Using the mean of the temperatures determined by the three methods even better results were obtained. J. S. Di.

1034. *Further Study of Haloes in Relation to Weather.* **H. H. Martin.** (Monthly Weather Rev. 46. pp. 119–120, March, 1918.)—After considering the available data the conclusion is reached that a halo does not in itself indicate the coming of rain, but that it does show the presence of a distant depression. If the subsequent changes of wind and pressure are noted, the direction of motion of the depression can be inferred. In this way only is the halo a help in forecasting rain. A bibliography of the subject is given. J. S. Di.

1035. *Haloes at Columbus, Ohio.* **H. H. Martin** and **J. L. Vesper.** (Monthly Weather Rev. 46. pp. 165–166, April, 1918.)—Describes unusual halo phenomena seen on two occasions, the first and more complex of these being illustrated. In addition to the usual mock-sun ring a circumzenithal arc touching the upper part of the 22° halo was seen, and this at the points of its intersection with the 46° halo gave an additional pair of mock suns, four of these being visible simultaneously. J. S. Di.

1036. *Whirlwind at Pasadena, Cal.* **F. A. Carpenter.** (Monthly Weather Rev. 46. pp. 178–179, April, 1918.)—During the afternoon of Jan. 26, 1918, a whirlwind of considerable intensity, showing many of the characteristics of a tornado, visited the city of Pasadena. This was the first of its kind reported from Southern California. The storm developed from a solitary cloud which formed in the neighbourhood of the town. It travelled south-eastward at first and then curved round anti-clockwise and ended up with a north-westward movement. It died out on a neighbouring mountain range, after having done extensive damage of the type associated with tornadoes along a path 200 ft. wide. The strong winds were very local as the Weather Bureau anemometer, which the storm skirted, showed no wind above 18 miles/hr. J. S. Di.

1037. *Nature of "z" Term in Latitude Variation.* **I. Yamamoto.** (Math. Phys. Soc., Tōkyō, Proc. 9. pp. 387–392, June, 1918.)—To test Shinjo's hypothesis, which attributes the z-term to anomalous atmospheric refraction caused mainly by changes of temperature in the observing room with daily and annual periods, the author with the assistance of M. Hashimoto observed at Mizusawa from May, 1914, to May, 1916, near the International latitude instrument, the instrument used being similar but on a rather smaller scale (75 % roughly), and the observing room specially designed to minimise the variations of temperature. The observations, being differential, are free from any errors depending upon the places of the stars or upon atmospheric conditions, and care is taken to eliminate as far as possible the instrumental effect, such as that due to the micrometer. He finds a sort of parallelism between his results and the International ones, which, however, are not yet published for the whole period, so that the comparison is not complete. There is a systematic difference between the latitudes indicated by the two instruments which points to the reality of the explanation offered by Shinjo. The "closing sum" from the observations is + 0·121″, very near in magnitude but not in sign to that usually found in "International" series. The resulting value of the aberration constant is 20·496″. W. W. B.

1038. *Variation of Latitude.* **F. W. Dyson.** (Roy. Astron. Soc., M.N. 78. pp. 452–462, May, 1918.)—The long series of international observations, beginning in 1900 at six stations, distributed in longitude (Mizusawa 141° E., Tschardjui 63° E., Carloforte 8° E., Gaithersburg 77° W., Cincinnati 84° W., and Ukiah 123° W.) provides material of much greater accuracy than any of the series employed by Chandler, and the present paper discusses them with a view to determining the free period of the rotation and testing its circularity and the constancy of phase and period, and also those of the annual term. A systematic closing error is ascribed to meteorological causes (*e.g.* a night shift of zenith), and the Kimura term is taken out separately. The author finds a mean free period of 432 days instead of Chandler's 428 days, so that 5 periods are nearly 6 years and 6 periods just over 7 years. He finds the free motion to be very nearly circular but of varying amplitude, the value about 1910 being much greater than that from 1900 to 1904, so that while the value for 1893 to 1906 was less than 0·30″, that for the last ten years is greater than 0·38″, and for 1910 and 1911 is 0·48″.

He also finds the annual term nearly circular, but possibly rather flattened at longitude 90°. W. W. B.

1039. *Vibrations of Tall Chimneys.* **Omori.** (Imp. Earthquakes Investigation Comm., Bull. 9. pp. 1–29, 1918. Nature, 101. p. 436, Aug. 1, 1918. Abstract. Engineering, 106. pp. 334–336, Sept. 27, 1918.)—From the point of view of stability, measurements of the vibrations of tall chimneys are important, especially in Japan which is subject to severe earthquakes. Experiments on 3 chimneys of concrete reinforced by steel rods are described by the author. One of the chimneys, erected by the Kuhara Mining Co. at Saganoseki, is the tallest in the world; it is 550 ft. high, 42 ft. 8 in. diam. at the base, and 27 ft. 5 in. at the top, the thickness of the wall being 29½ in. at the base and 7 in. at the top. The total weight of the structure, including the foundation, is 9500 tons, and the pressure of the shaft on the ground below is 3 tons per sq. ft. Measurements were made on 5 days by means of 2 horizontal vibration recorders fixed to the top of the wall. The wind at the top attained a velocity of 24 m./sec. on the first day, and the high value of 35 m./sec. on the last; on the 3 intervening days it never exceeded 7 m./sec. With the latter velocity the vibrations of the chimney were insignificant, but they increased rapidly with the strength of the wind, the range (or double amplitude) being 20 mm. in the direction of the wind and 186 mm. at right angles to it. The period of the vibrations was almost constant and varied from 2·52 to 2·58 secs., the max. acceleration being 565 mm. per sec. per sec., or nearly one-third more than that of the semi-destructive Tōkyō earthquake of 1894. Omori notices that the period of vibration is distinctly greater than that of the strong vibrations of a great earthquake (which is usually from 1 to 1½ secs.), and concludes that, in a district such as Saganoseki, in which the earthquakes are by no means violent, the effects of wind-pressure are likely to be more important than those of earthquake motion. H. H. Ho.

1040. *Denudation by Rain Run-off.* **H. Jeffreys.** (Phil. Mag. 36. pp. 179–190, Aug., 1918.)—The problem of denudation by rain freely running off a surface is treated dynamically. The movement of surface water is controlled by gravity and friction; hydrostatic pressure and inertia are negligible. Water, therefore, always moves along the lines of greatest slope. In mountainous regions the friction may be due to turbulence, but usually to viscosity. The motion is completely determinable given the form of the land and the rain distribution. In the case of viscous flow the rate of denudation is proportional to the product of the depth of water and the tangent of the slope. If this is constant the surface will sink at a uniform rate. W. A. R.

1041. *Katmai Eruption in* 1912. **R. F. Griggs.** (Nature, 101. pp. 497–498, Aug. 22, 1918.)—No definite records of earlier activity exist. The whole summit was blown away, and the resulting crater is the largest known. The bottom is filled up by a hot-water lake through which emerges a single-breached cone. The ejecta were widely distributed—appreciable falls occurred 1600 miles away. The amount of ash far surpasses that of Krakatoa, but the atmospheric effects, though world-wide, were much less pronounced. The most interesting concomitant with the eruption is the Valley of a Thousand Smokes. Originally a system of grass-grown valleys; it is now occupied by several millions of vents giving forth columns of vapour and gas. The high temperatures prevailing prevent the formation of hot springs and geysers, which might be expected. W. A. R.

1042. *Temperature Measurement in Borings.* **Verzat.** (Comptes Rendus, 167. pp. 203–204, July 29, 1918.)—A simple arrangement of two maximum thermometers with bore narrowed at 40° C., one of which was inverted, and both read by comparison with a standard, was successfully used to measure the basal temperature of the deep boring (5300 ft.) at Saint-Jean d'Héraus. The effect of circulating waters was eliminated because the instruments were surrounded by sediment that choked the bottom on lifting the core. The temperature gradient was 1 deg. F. in every 58·9 ft. W. A. R.

1043. *Location of Epicentres for* 1916. **E. A. Hodgson.** (Roy. Astron. Soc. Canada, J. 12. pp. 251–267, July–Aug., 1918.)—The annual publication of epicentres, begun in 1911, has been carried to the end of 1915. This article continues the series through 1916. For well-marked quakes the times at the epicentres from the various stations—from China and Japan, South America, England, Africa, Australia, Alaska, etc.—agree within a few seconds with the records obtained in the United States and Canada.

During the year 1916 there were 105 earthquakes recorded at Ottawa. Not all were of a nature which enabled the distance to be obtained at Ottawa, but all are entered in the list. Of these 32 yield a good location, 26 an approximate location, and 48 no location. It is noted how the latter appear in large groups about April 2 and October 3 in this particular year. E. O. W.

1044. *Secular Perturbations of the Inner Planets.* **H. Jeffreys.** (Phil. Mag. 36. pp. 203–205, Aug., 1918.)—The author takes the values of the perihelion motions of Mercury, Venus, the Earth, and Mars derived from Silberstein's theory of general relativity without the equivalence hypothesis instead of the values calculated from the Newtonian law, and computes the position of disturbing matter near the sun which will best satisfy the observed values of the perturbations of the inclination, node and perihelion of Mercury, Venus, and Mars. Of these nine quantities, three would be expected to show residuals greater than their mean errors. The author's result comes out with only one of the quantities, the perturbation of the perihelion of Mars, having a residual greater than its mean error. He concludes that a reasonable amount of gravitating matter near the sun will satisfactorily account for the residuals. W. W. B.

1045. *Contraction and Evolution of the Sun.* **A. Véronnet.** (Comptes Rendus, 166. pp. 642–645, April 22, and pp. 812–815, May 21, 1918.)—Considering the sun as a mass of gas, contracting at such a rate as to counterbalance the loss of heat by radiation, which is of course proportional to the square of the radius and, by Stefan's law, to the fourth power of the surface temperature, the author obtains an expression for the rapidity of contraction as a function of the radius and the time, which are also connected by the formula of dilatation. Adopting the value of 15 million years for the sun's previous history he deduces upper and lower limits to the duration of the present set of conditions (cooling under contraction, density nearly uniform). For any value of the dilatation constant he finds the period to be less than a million years, while for values 3 and 7 of the constant he obtains lower limits of 750,000 and 870,000 respectively. The probable value he sets at between 900,000 and a million years. He also concludes that the rate of cooling is proportional to the 18th power of the radius. Increasing the radius 10 % multiplies this rate by 6 and increasing it 20 % multiplies the rate by 60. Therefore, he says, we need not go further back than a value 6/5 of the present radius, as the previous history would not occupy 65,000 years. The temperature at that time would have been double the present value. Concluding that the radius and temperature, and consequently the physical condition, of the sun can never have been different from what they are now, he applies the rate of cooling he has found for the sun to the case of the earth and predicts that the mean temperature of Paris will fall to the freezing-point in 200,000 years and at the equator in 600,000 or, possibly, 800,000 years. In the second article the author gives tables computed by L. Deissard for different values of the sun's radius within 20 % of the present value, and for a few different values of the cubical dilatation constant. A probable value of 910,000 years is inferred in agreement with his previous conclusions, and a value of 7 for the dilatation constant. It is predicted that the rate of cooling will become much slower, that in 4 million years the radius will be one-tenth less, with a temperature of 4200°, and in 10 million years the radius will be one-seventh less (with temperature of 3500°), which will mean the liquefaction of the surface gases, with rapid cooling and extinction of the sun's light. W. W. B.

1046. *Diffraction of Solar Images.* **M. Hamy.** (Comptes Rendus, 166. pp. 878–881, June 3, 1918.)—The author has been studying the diffraction of the focal image of the sun produced through an objective covered with a diaphragm in which is a narrow slit, and on the analogy of the improvement in optical power of an object-glass with its centre covered up, he devotes the present paper to seeing whether the blocking up of the centre of the objective slit will also cause an improvement in the sharpness of the image. He finds that lengthening the slit improves the images, but blocking out the central portion does not. W. W. B.

1047. *Surface-currents of Jupiter,* 1917–18. **S. Bolton.** (Roy. Astron. Soc., M.N. 78. pp. 467–471, May, 1918.)—The author has continued to study the longitudinal drift of surface matter in different latitudes in order to determine the various rotation periods [see Abs. 743 (1917)]. More than 6000 transits across the central meridian are employed in the final reduction, giving 32 different mean rotation periods which are summarised in a shorter table, the equatorial current giving a mean period 9h. 50m. 14·2s. and the other spots and disturbances varying between 9h. 55m. 8·2s. (S. Temperate spots) and 9h. 55m. 52·9s. (slow N. Temperate spots); the Red Spot Hollow gives 9h. 55m. 34·3s. The relative motion of certain of the markings is noted in detail; there are also notes on changes observed in different latitudes and on the colours of the various belts. W. W. B.

1048. *Motion in Longitude of the Red Spot on Jupiter.* **T. E. R. Phillips.** (Roy. Astron. Soc., M.N. 78. pp. 630–634, June, 1918.)—Contains a summary of observations, from 1894 to the present time, of the rotation periods of the Red Spot, (1) during the intervals from one opposition to the next, (2) as deduced from transit observations during the planet's apparition. In comparing these periods with the rotation period of the S. Tropical Disturbance, the author contends that the differences are due to a phase-darkening effect which causes a spot's transit to be recorded too early at the beginning of an apparition and too late at the close; also that the varying slant of the belts before and after opposition may help to cause such an effect. If the contention is correct, the rotation periods derived from observations during the planet's visibility are all slightly too long. [See also Abs. 1629, 1631 (1915) and 201 (1917).] H. F. H.

1049. *New Theory of Jupiter's Satellites.* **W. de Sitter.** (K. Akad. Amsterdam, Proc. 20. 9. and 10. pp. 1289–1308, 1918.)—To evade the difficulty arising from the commensurability of the mean motions of the first three satellites, the author starts from an intermediary orbit, in which the great inequalities (caused by the commensurable motion) come in as excentricities, and proceeds to add the rest of the perturbations and variations due to the want of exactness of the constants of integration. The fourth satellite is not quite so well suited; but by choosing for origin an opposition of the second and third satellites from which the longitude of the fourth is nearly an exact multiple of π, he obtains for the intermediary orbit a Keplerian ellipse, which he finds for the first three satellites to be a better approximation than the fixed Keplerian ellipse, while for the fourth satellite it is nearly a circle.

The second part of the paper discusses the variational equations, pointing out the deviations which do not essentially alter the intermediate orbit, and also that by choosing constants and zero to make certain coefficients vanish, an equation of the 16th degree can be brought down to one of the fifth, while similar simplifications are applied to the perturbations. The full theory of these latter has been published elsewhere (Leiden Observat. Annals, vol. 12). W. W. B.

1050. *Asteroid Groups Probably of Common Origin.* **K. Hirayama.** (Math. Phys. Soc. Tōkyō, Proc. 9. pp. 354–361, June, 1918.)—The author finds certain values of mean motion, inclination, and eccentricity of asteroid orbits occurring too frequently to be due to chance, and investigates three such groups of values. Of 37 asteroids with mean motion between 720″ and 740″, he finds 16 with an inclination of less than 4°, and of these 16, ten have eccentricity also less than 4°. Again plotting on a diagram the poles of the

16 orbital planes he finds 15 of them lying close to a circle about the poles of Jupiter's orbit. Also taking eccentricity and longitude of perihelion instead of inclination and longitude of node, 13 points are on a circle. This group of 13 asteroids he calls the Koronis family, as the oldest known number is 158 Koronis. Similar relations give two more such families, named from 221 Eos, and 24 Themis, and consisting of 19 and 22 members respectively. His theory explains the families as the fragments of larger asteroids, giving reasons why in course of time the change in angular velocity alone remains important, if the additional velocities of the fragments are small compared with the original velocity, causing the circular distribution of the poles, of which he gives diagrams for the three families investigated, as well as lists of the asteroid numbers belonging to them. W. W. B.

1051. *Why Gaps occur in Asteroid Mean Motion Distribution.* **K. Hirayama.** (Math. Phys. Soc. Tōkyō, Proc. 9. pp. 264–268, April, 1918.)—The author confines himself to the principal perturbations of the asteroids and makes certain simple assumptions as to resisting particles, namely: that they move round the sun in direct circular orbits in asteroid plane, that their resistance varies as the square of the relative velocity, and their density is a continuous function of the radius vector. Then considering motion only close to the commensurable points, he considers six possible cases, *i.e.*, revolution or libration, on one or the other or both sides of the commensurable point, with a view to testing the stability, and finds that the only case which is really permanent is that of revolution on the positive side, all cases of libration ultimately changing to revolution. W. W. B.

1052. *Orbit of Spectroscopic Binary Boss* 46. **W. S. Adams** and **G. Strömberg.** (Mt. Wilson Solar Observat., Contrib. No. 149. Astrophys. J. 47. pp. 329–335, June, 1918.)—The Ca lines indicate a small variation in velocity of about 20 km. with the same period as shown by the H and He lines; between the two latter the variation of velocity is nearly 450 km. The motion of the system as derived from the two sets of lines differs by about 20 km. A displacement of the Ca lines relative to the other lines might arise from a marked difference in the distribution of gases around the stars, but a probable source of difference may be the presence of the spectrum of the secondary component. Measurements of velocity of the latter have been made on a very few plates, but too few for use in calculation of the orbit.
H. F. H.

1053. *Perturbations of the Orbit of Olbers' Comet.* **F. K. Ginzel.** (Preuss. Akad. Wiss. Berlin, Ber. 32. pp. 669–676, 1918.)—The author has previously, in 1881 and 1898, published investigations of this comet's orbit. He now supplements that information by dealing with the perturbations due to Mars, caused some few months before perihelion in 1887. L. H. W.

1054. *A Spectroscopic Study of* β *Canis Majoris.* **F. Henroteau.** (Lick Observat. Bull. 9. [No. 311], pp. 155–161, 1918.)—The author's spectrograms of 1917 and 1918 show variations in the widths of lines approximately once in each period of velocity variation, the max. widths occurring at different places on the corresponding velocity curves. There also appears to be a variation of intensity of the lines. Neither effect seems due to a combination of two spectra. After advancing possible explanations, the author admits it is hard to explain all the phenomena. H. F. H.

1055. *Radial-velocity Determinations with the Objective Prism.* **M. Hamy.** (Comptes Rendus, 167. pp. 9–12, July 1, 1918. Errata, *Ibid.* p. 100, July 8, 1918.)—The author's previous method is improved and simplified. Two similar prisms are fixed with bases facing each other at such an angle that parallel rays can traverse both at nearly the same angle. Separate objectives give monochromatic images in thin focal planes. A sighting eyepiece is necessary to ensure the angle of incidence being practically always the same, and the method of mounting makes the instrument free from flexure parallel to the dispersion. The method consists in photographing comparison spectra on the same plate as the spectrum under investigation and deducing from the angular distance between corresponding rays the difference of the squares of the refractive indexes of the prism for those rays, and hence the alteration in wave-length, which gives the radial velocity. W. W. B.

1056. *High Velocities of Novæ, and "Whirlpool" Cosmogony.* **E. Belot.** (Comptes Rendus, 166. pp. 898–900, June 3, 1918.)—The author defends his value (75,000 km. per sec.), calculated for the velocity of the solar nebula at its first catastrophe, when it blazed up as a nova. His big figures are, he says, only relative, and this 74,830 km. for the initial velocity is obtained from a formula connecting it with the actual velocity in space (20 km. per sec.), and might just as well be derived from an actual velocity of 1 km., giving 3740 km. not widely different from the 2000 km. computed in the actual case of Nova Persei. Hence, he says, there is no improbability on the ground of velocity, in the "whirlpool" cosmogony. Unfortunately the suddenness of the light-changes in novæ at the initial stage has prevented the taking of spectrograms which might confirm the suggested high value as a possibility. W. W. B.

1057. *Intrinsic Brightness of Starlight.* **H. Bourget.** (Comptes Rendus, 166. pp. 943–945, June 10, 1918.)—Observations by C. Fabry's method were made on moonless nights in Aug. and Sept. 1917, far enough from Marseilles to be unaffected by the town lights. The general light of an area of 1·22 sq. degrees of the sky is supposed to be compared photographically with that of a single star of about fifth magnitude, but the author, finding it difficult to change his diaphragm for the smaller one without altering the adjustment of the instrument, compared his areas with a standard area including ι Ursæ Minoris, a fifth-magnitude star. Of 23 plates dealing with 40 separate areas, he finds 16 satisfactory and gives the resulting brightness, and after comparing the limited data thus obtained, he concludes that, for unit area, the Milky Way is 1·7 times as bright as the rest of the sky. W. W. B.

1058. *Contraction of Stars and Equilibrium of Nebulæ.* **A. Véronnet.** (Comptes Rendus, 166. pp. 901–903, June 3, 1918.)—Starting with the principle of the equivalence of heat and work, the author investigates the amount of heat developed in their contraction for different celestial bodies. The time taken by the sun in cooling 1 deg. C. he finds to be lengthened on this account by 7700 years, so that the complete cooling requires millions of years instead of thousands. For Jupiter the lengthening per 1 deg. is measured in hundreds of years, but for the earth it is only a few years; but as the interior of the earth is not gaseous, the cooling is only superficial and the contraction negligible. For a mass of gas he finds the max. temperature occurs when the density becomes one-fourth of the limiting density of the gas. W. W. B.

1059. *Maximum Temperature of a Condensing Star.* **A. Véronnet.** (Comptes Rendus, 167. pp. 67–69, July 8, 1918.)—The author having found [see preceding Abs.] that the max. temperature of a condensing gaseous mass is reached when the density is one-quarter of the limiting density of the gas, proceeds to determine the physical conditions corresponding to that value. Assuming as before that at 0° the sun's radius would be halved and its density increased eightfold, he obtains pressures of 1400 and 1240 atmos. respectively, according as the coefficient of cubical or linear dilatation is taken as constant. These pressure values under the two dilatation hypotheses lead to central temperatures of 57 million and 3 million degrees respectively, with radii 34 times that of the sun in the one case and 213 times in the other. If, however, the star, instead of being similar to the sun, consists only of hydrogen, these temperatures will be 220,000° and 73,000°, and the radius in the second case only 118 times that of the sun at present. This being the condition at the centre, the mean values will not be different if the max. temperature can be reached suddenly to avoid loss by radiation. Hence a collision may be necessary. Moreover, the contraction will be too rapid and equilibrium will be upset, causing a fresh catastrophe. These stars will hence be variable.

The author thinks the variability of the sun may be a relic of some such state as this in the past. W. W. B.

1060. *Pulsation Theory of Cepheid Variables.* **F. A. Lindemann.** (Roy. Astron. Soc., M.N. 78. pp. 639–640, June, 1918.)—On the pulsation theory, that variations in radial velocity are due to alternate contraction and dilatation of the star, the light from the rim should show no change of radial velocity, so that the lines would simply broaden on alternate sides. The author suggests that this will afford a test of the theory and, if true, a method of determining the parallax. The maxima and minima of magnitude correspond closely to periods of maximum and minimum radial velocity, so that a large change of temperature has only involved a small change in radius, indicating a slow flow of heat from the centre. The author allows that this may weaken the method suggested, but thinks that a careful test should be made on some Cepheid such as SU Cassiopeiæ, of which radial velocity, magnitude, spectral type, and temperature are known as functions of the time, and its parallax determined in order to decide the validity of the pulsation theory. W. W. B.

1061. *Periodicity in Solar Variation.* **C. G. Abbot.** (Smithsonian Misc. Coll. 69. pp. 1–8, June, 1918.)—Comparing daily values of the solar constant with those on succeeding days when possible up to the 40th day, correlation coefficients are determined and plotted for the years 1908 to 1916 (omitting 1912 when the Mt. Kamai volcano vitiated the results). No well-marked periodicity persists through the whole period. In all the years except 1916 there is positive correlation on the first day, showing that the variations are not accidental errors of observation. In 1915 the solar rotation period is indicated, and one side of the sun appears to be hotter than the other. In 1916 a well-marked period of 3½ days is shown. In 1909, 1910, and 1914, which are rather similar, a periodicity of 7½ days is indicated. In the remaining years 1908, 1911, and 1913, there is no reasonable evidence of periodicity at all, and no similarity between the years. W. W. B.

1062. *Short-period Variable RS Boötis.* **C. Martin** and **H. C. Plummer.** (Roy. Astron. Soc., M.N. 78. pp. 640–643, June, 1918.)—This is another item in the Dunsink series of photographic light-curves. The period is about 9 hours, and is given more accurately as 0·3773335. The magnitudes of the comparison stars are derived from a single plate exposed at equal altitudes on the region of the variable and on the χ Persei cluster, for which Schwartzschild's magnitudes are used. The magnitudes of the star varies from 9·7 to 10·9, and the resulting light-curve is compared with one determined visually by Seares. Forty-two photographs are employed in the series. W. W. B.

1063. *Eclipsing Variable W Ursæ Minoris.* **C. Martin** and **H. C. Plummer.** (Roy. Astron. Soc., M.N. 78. pp. 644–649, June, 1918.)—Another of the Dunsink series [see preceding Abs.]. Seventy-six plates have been used, and the period is given as 1·701213 days. The magnitude at the stationary phase is 8·75 ± 0·005, at primary minimum 9·64, and at secondary minimum 8·88 ; but this is uncertain, owing to the comparison stars being badly distributed. Solutions are obtained on the alternative assumptions of partial eclipse of uniform stars and darkened stars, and the latter is shown to be the more probable, while total eclipse at primary minimum appears to be impossible. More observations are required. W. W. B.

1064. *Stellar Currents.* **J. C. Solá.** (Comptes Rendus, 167. pp. 271–273, Aug. 12, 1918. Observatory, No. 530. pp. 339–343, Sept., 1918.)—In the opposite part of the heavens to that studied in a previous paper [Abs. 750 (1918)], the author has compared stereoscopically two pairs of plates of the constellation Virgo ; one pair 1912 and 1918, the other 1916 and 1918. He confirms his previous supposition of a general East to West current, and that the spiral nebulæ are universes beyond the Milky Way. Of 76 "parcels," 3 are doubtful, and of the rest 61 have currents included in an angle of 162°. The stars down to the tenth magnitude form, he considers, a large mass or cluster, rotating generally about the solar system and within the galaxy. W. W. B.

1065. *Precession-constant and Systematic Proper Motions of the Stars.* **C. de Jong.** (K. Akad. Amsterdam, Proc. 20. 7. pp. 956–965, 1918.)—This is a second instalment of a large scheme of comparison of Küstner's Catalogue with others. The present paper deals with Bessel's zone observations between 0° and + 15° Declination. Excluding 29 double stars the two catalogues have 1489 stars in common, the difference of epoch being 72·2 years. Several other zone catalogues are used directly or indirectly in the determination of the zone-errors of Bessel's stars. Several hundred stars are omitted on account of large proper-motion or various anomalies showing up in the comparison of catalogues. The resulting value of the luni-solar precession for 1850 is 50·3709″, and the author compares his figures with those of Newcomb, Kapteyn, Dyson, Boss, and others. The results for the elements of the solar motion are also compared, and the anomalous values for the apex derived from faint stars discussed. Among the author's conclusions may be noted : (1) Bessel's magnitude error must be very small. (2) A cosmic phenomenon such as general streaming of bright stars with reference to faint ones is a plausible suggestion to account for the anomalies of the apex-determinations, but there is no ground for it *a priori*, and it cannot yet be accepted. (3) Nothing can be deduced as to the general rotation of the stars from the present material. W. W. B.

1066. *Nova Aquilæ* (1918). **H. Thomson.** (Roy. Astron. Soc., M.N. 78. pp. 575–576, June, 1918.)—The author, one of the early discoverers of the nova, gives his impressions of the brightness, as equal to Altair on June 8, half a magnitude brighter than Vega on June 9, equal to or rather brighter than Arcturus on June 10; and between Vega and Altair in brightness on June 11. He also gives details of his ocular spectroscopic observations taken frequently during each night, with the relative changes in the hydrogen lines, and the rapid increase from night to night in the number of lines observed. (Roy. Astron. Soc., M.N. 78. pp. 577–578, June, 1918.)—Visual observations of the spectrum were obtained at Cambridge with a direct-vision prism on 4-in. telescope; photographs were very faint on the first few nights, but more satisfactory on June 13 with comparison spectrum of the iron spark and also of α Cygni, to which some features of the spectrum of the Nova show great similarity. **Laskovski.** (Marseilles Observat. Circ. No. 25. Nature, 101. p. 375, July 11, 1918. Abstract.)—Particulars are given of an observation at Geneva on June 7 at 9.45 p.m. mid-European time of the Nova as a white star intermediate in magnitude between α Ophiuchi (2·1) and Altair (0·9). This is apparently the earliest reported observation. **F. W. Dyson, A. Fowler.** (Nature, 101. pp. 285–286, June 13, 1918.)—Dyson gives a summary of various independent discoverers of the Nova; and of R. Jonckheere's identification of it with a star on the Algiers Chart, Zone + 1°. Fowler gives details of spectroscopic observations on June 10 and 11 at South Kensington. Red line of hydrogen very bright; four bright lines in the green, probably H_β and three enhanced iron lines; one in the blue, probably H_γ, with a few other lines whose approximate wave-lengths are given. **W. E. Harper.** (Roy. Astron. Soc. Canada, J. 12. pp. 268–270, July–Aug., 1918.)—The paper contains the Ottawa spectroscopic observations of the Nova from June 9 to 23, with preliminary determinations of the displacements towards the violet of the chief absorption bands. From the sharp H and K lines a velocity of approach to the solar system of 22 km. per sec. has been determined from 11 plates so far measured. The progressive changes from night to night are briefly noted and a plate gives a nearly 6-fold reproduction of the spectrum on June 9, 10, 15, 17, and 23. (Nature, 101. p. 375, July 11, 1918.)—**W. F. Denning** reports a slight recovery in brightness at the beginning of July at about the same interval from maximum as was noted in the case of Nova Persei. **A. Fowler** noted no striking changes in detail of the spectrum between June 29 and July 8, except that the reversal of the hydrogen lines is no longer clearly visible. The band in the blue near $\lambda 464$ remains conspicuous and possibly increasing in relative brightness. **T. E. R. Phillips** reports remarkable changes in structure of bright hydrogen bands between June 13 and July 4, a new bright band appearing on the latter date. (Nature, 101. p. 492, Aug. 22, 1918.)—**P. Blanc's** observations of brightness from June 8 to 30 come from Circular No. 27 of Marseilles Observatory; also determinations by Maggini at Florence from three lines in the spectrum, indicating that the nova does not radiate as a black body. **C. Easton** gives references to previous observations of variability of the nova before its recent outburst. **I. Yamamoto** and **Y. Ueta**, of Kyōtō University, confirm a slight recovery from June 29. **A. Fowler** reports that on Aug. 10 the most conspicuous line in the spectrum is the green nebular line. **A. L. Cortie** sends wave-length determinations obtained on Aug. 13 and 15 of several bright bands, some being double and triple, and recalls that the spectrum of Nova Persei in Aug. and Sept. 1901 was very similar. **R. Jonckheere.** (Comptes Rendus, 167. pp. 64–67, July 8, 1918.)—Jonckheere gives an account of his observations with the 28-in. equatorial at Greenwich, describing the changes from night to night in the appearance of the nova, with his determinations of the magnitude by means of a wedge photometer, using Altair as his only standard of comparison. Other observations comparing the nova with Vega and Arcturus are omitted. He then identifies the star with one on a Franklin-Adams chart (Johannesburg, 1910 Aug. 3), Algiers Astrographic chart, 1909 Aug. 20, and Algiers Catalogue from a photograph 1895 June 26. These agree with an observation taken at Greenwich with the Transit-Circle on 1918 June 10. **F. de Roy.** (Comptes Rendus, 166. pp. 1043–1046, June 24, 1918.)—de Roy's discovery was made at Thornton Heath on June 8 at 22.45 Greenwich mean time. He thinks the nova could not have been conspicuous on the previous evening. The comparison stars being distant and at different altitudes the fractional method is used instead of that by steps, and all observations corrected to the zenith. He finds the mean magnitude for the nights from June 8 to 13 to be 1·08, 0·61, 0·35, 0·51, 0·60, and 0·97 respectively (that on June 9 being obtained by extrapolation), the nova being brighter than any other star then visible. Probably no historic nova was so bright as this except Tycho's nova of 1572. **J. Bosler.** (Comptes Rendus, 166. pp. 1042–1043, June 24, 1918.)—Plates taken at Meudon June 12 and 15 show the ordinary hydrogen series and several other lines, as found in other bright novæ, including Nova Persei and Nova Aurigæ, each bright line being accompanied by one or more absorption bands spreading out towards the violet and none displaced towards the red. The changes between the two nights are not striking; some doublets on June 12, however, appeared on June 15 as one line with a complicated structure replacing the comparison line. The velocity of approach deduced from displacements is so great, 2300 km. per sec., that it seems rather doubtful if they will be accepted, though spiral nebulæ have lately shown some very high values. W. W. B.

1067. *Applicability of the Kinetic Theory of Gases to the System of Fixed Stars.* **J. Lense.** (Phys. Zeits. 19. pp. 182–187, May 1, 1918.)—Recently C. V. L. Charlier has published several papers on the application of the methods of the kinetic theory of gases to the system of fixed stars. The present author now enquires as to which state of a gas will afford a model on the large scale of the star system. To this end he compares the latter with hydrogen at 0° and 760° C. Both are assemblies of individuals, in the one case of molecules, in the other of stars. In order to have comparable cases, the stars are all assumed to be of the same size and mass as the sun, the Milky Way being replaced by a spherical system of radius 10^9 of that of the earth's orbit. This assumption was discussed and adopted by Poincaré and also by Charlier; it should afford approximately the relations in the fixed-star system. The astronomical unit of volume, *i.e.* a cube whose side is equal to the average distance between earth and sun, will therefore contain $3 \times 10^{-18}/4\pi$ stars. The c.g.s. system is chosen as the mass system of the gas. The density relationship and the average distance between two individuals in both systems are first calculated.

Section 2 of the paper deals with impact. Here Maxwell replaced his earlier hypothesis of equally great, perfectly elastic, spherical gas molecules having uniform motion, by another in which particles have equal mass but varying shape and collide with a force inversely proportional to the fifth power of the distance; these only move linearily and uniformly again when without the spheres of activity. In this case, instead of elastic impacts there occur transition processes which deflect the particle from its rectilinear path. This type of impact always occurs in the case of stars. Section 3 investigates the mean free path of individuals in the system.

Section 4 examines the sphere of activity around a star, employing as an example the case of comets being captured by the sun. The gas spheres and star systems are thus seen to be assemblies of many single particles which attract, according to the Newtonian law, and which, in consequence, cannot move away indefinitely, but must form closed systems. Many similarities are shown to exist between the two systems, but an exact analogy is, of course, not asserted. H. H. Ho.

1068. *Spectrum of Mira.* **W. S. Adams** and **A. H. Joy.** (Astron. Soc. Pacific, Publ. 30. p. 193, 1918. Nature, 101. p. 492, Aug. 22, 1918. Abstract.) —The authors find that, excluding the hydrogen lines, the bright lines are mainly due to Fe and Mg, and are those associated with low temperature, the brightest being the magnesium line λ4571, the most characteristic line of the flame spectrum. These lines become more intense towards minimum, thus pointing to a reduction of temperature along with that of brightness. W. W. B.

1069. *Mean Distances of Stars of Different Spectral Types.* **S. Hirayama.** (Math. Phys. Soc., Tōkyō, Proc. 9. pp. 361–369, June, 1918. Nature, 102. p. 97, Oct. 3, 1918.)—This is an endeavour to extend to further spectral types the evaluation of constants in Kapteyn's formula connecting parallax, mean magnitude and proper motion, which Kapteyn and van Rhijn have done for three types only. The author, starting with a list of 500 stars whose luminosities and parallaxes are given by Adams and Joy, discards all but those with positive measured parallaxes. For types A and B, which are not represented in Adams and Joy's list, van Rhijn's constants are entered, but for the other classes one of van Rhijn's constants is taken as invariable, and the other two are computed for thetypes F_{0-5}, F_{6-9}, G_{0-5}, G_{6-9}, K_{0-3}, K_{4-9}, and M.

A table is given comparing the parallaxes derived from the author's formula, and those determined spectroscopically, with the measured trigonometrical parallaxes. He finds his values show a larger mean error than the spectroscopic ones, but this he attributes to a few stars with abnormally large residuals. He next proceeds to test the constancy of the third constant which he provisionally used as invariable, but fails to improve his residuals by any such adjustment. He tabulates his results with diagrams showing the variation with spectral type of the distances of stars of the fifth magnitude and with proper motion of 1″, 0·1″ and 0·01″ respectively. His parallaxes come out about twice as great as Kapteyn's, but he is satisfied that the correlation he has been studying is real. W. W. B.

1070. *Visual Magnitude Scale and Star-counts.* **R. H. Tucker.** (Lick Observat. Bull. 9. [No. 312], pp. 162–169, 1918.)—This is an exhaustive discussion of the accuracy of the limiting magnitudes included in the several counts of the sky covered by Uranometries and the Durchmusterung, with special reference to the work at Cordoba. It also includes tests of the light ratio between different magnitudes and of the value of star-counts. The author's own work at Cordoba includes a count of 37,000 stars in representative parts of the first ten degrees of the Cordoba Durchmusterung, as well as the greater part of the observations in the first two volumes. He notes the change of scale at the ninth magnitude of Argelander, and justifies the adoption of a different number-ratio at the limit of naked-eye visibility. The different screens in use for determining light ratio are compared, and numerical relations are given between the units of the various photometric scales—Argelander, Schönfeld, Harvard, and the different Cordoba scales.

The number of stars to the square degree in different zone catalogues supplies a further test.

The author specially praises the Cordoba zone work (—22° to —27°), regarding it as a proof of the excellence of the Cordoba climate, the telescope used being only of 5-in. aperture.

Finally it appears to be established that the visual scale limit of 9·5 magnitude corresponds to 9·4 for Argelander's northern sky and to 9·8 for Schönfeld's zones, to 9·2 for the first two Cordoba volumes, and 9·5 for the third and fourth, while for the Cape Photographic Durchmusterung the corresponding limit would be 9·3. W. W. B.

1071. *Nova Monocerotis.* **G. F. Paddock.** (Lick Observat. Bull. 9. [No. 313], pp. 170–172, 1918.)—This star was not visible, or was fainter than 9·8 mag. on Dec. 22, but was of magnitude 5·4 on a Harvard photograph of Jan. 1. It was not discovered, however, until Feb. 4 (by Wolf at Heidelberg), decidedly past its maximum, having visual magnitude about 8¼. The paper gives details of spectrum plates taken in Feb. and March (most of them by the author at Lick Observatory with a single prism and 16-in. camera) with particulars of the plates used, some of them stained. The approximate wave-lengths and displacements of emission and absorption bands are tabulated. The author finds in general a faint, broad absorption band over the middle of every emission band. The hydrogen bands are nearly symmetrical, but in both nebulium bands the bright parts are stronger towards the violet, unlike those of Nova Geminorum No. 2. There are no narrow lines available for radial-velocity determination. The nova has obviously reached the nebular stage in its development. W. W. B.

1072. *Period of Sirius.* **R. Jonckheere.** (Roy. Astron. Soc., M.N. 78. pp. 480–483, May, 1918.)—The author has obtained 30 observations of this binary during the last four winters, with the Greenwich 28-in. refractor, and from these, together with 34 observations made by E. E. Barnard during the same period, to which double weight is assigned as they were taken with the 40-in. Yerkes telescope, he deduces corrections to the orbits determined by See (1895), Doberek (1903), and Lohse (1908), and finds the period to be almost exactly 50 years; in close agreement with the determination made principally from Greenwich transit observations in 1851, before the companion was discovered. W. W. B.

1073. *Spectral Characteristics of Cepheid Variables.* **W. S. Adams** and **A. H. Joy.** (Nat. Acad. Sci., Proc. 4. pp. 129–132, May 15, 1918.)—The authors choose the Cepheid variables for special investigation on account of their very high intrinsic luminosity, computed at from 100 to 500 times as great as that of the sun. By means of a Hartmann spectro-comparator, they compare the spectra of nine of these stars at maximum and minimum with each other, with that of the sun as representing types G_0, and with those of typical stars of types F_0, F_5, and G_5. The hydrogen lines being abnormally strong in the Cepheid spectra, two comparisons are made, one of the hydrogen lines only and one of the general spectrum. The mean type in the former case comes out at F_1 for maximum and F_7 for minimum, but in the latter case the types are respectively F_9 and G_0, showing very little difference in the general spectrum, but a great deal in the hydrogen lines. Thus the main variation in the Cepheids is that of the intensity of the hydrogen lines. The authors are therefore averse to drawing conclusions as to the order of evolution of stars in general from the variations in Cepheid spectra. They find, however, some other differences between maximum and minimum, besides those of the hydrogen lines, including (1) a shift of the maximum of the continuous spectrum towards the violet at maximum, (2) a general slight widening of lines at minimum, and (3) an increase in intensity of "enhanced" lines at maximum, which are much more intense than in the solar spectrum. These include lines of Sr, Fe, and Ti, one of the Sr lines (λ4077) being in some of the stellar spectra five times as strong as in the sun. The authors compute the difference in magnitude between maximum and minimum from the intensities of three of these lines, obtaining a mean result in good agreement with the photometric value.

The authors note that while in the sun H_β is much more intense than H_γ, the reverse is the case in the Cepheid spectra; this difference is attributable to the much higher temperature in the Cepheid variables: increase of temperature having been found to shift the maximum of intensity towards the violet. Some of the characteristics noted above are found also in certain other stars near the galactic plane. W. W. B.

1074. *Real Motions of Stars.* **B. Boss.** (Astron. J. 31. pp. 121–132, June 13, 1918.)—From the parallaxes determined by Adams and Joy spectroscopically, the author selects 219 stars whose proper motions and radial velocities have been published and computes for each of these the apex and the velocity in space. The apices are set out in diagrams first in general, next in classes of large proper motion (<0·2″) and small proper motion (<0·1″), and then in divisions of "giant" and "dwarf" stars. The resulting solar motion and apex are discussed and space velocities deduced for the different groups, comparison being made with the results of other investigators. Some of the main general conclusions are:—(1) There is a definite solar group moving in the direction A = 270·3° D = + 15·7° at the rate of 22 km. per sec. and composed mainly of giants. (2) The dwarfs probably belong to the same system, as they give a solar motion not widely different. (3) Giants and dwarfs together give solar motion A = 269°, D = + 30°, velocity 23·8 km. per sec., which latter is nearly the mean of the results from radial velocity and from proper motion. (4) Giants and dwarfs have distinctly different velocity figures, both in orientation and relative length of axes: the dwarfs have a fairly symmetrical velocity figure, while that of the giants resembles a clover-leaf. (5) The orientation, though different for giants and dwarfs, is independent of spectral type, but the axes of the figure are dependent on both these classifications. W. W. B.

1075. *Cause of Distance-Velocity Equation in Stellar Motions.* **C. D. Perrine.** (Astrophys. J. 47. pp. 179–188, April, 1918.)—Recently suggested correlations between radial velocity, magnitude, proper motion, parallax and spectral type of stars have been provisionally attributed to the action of cosmical matter. The author finds, however, on investigation that taking the ellipsoidal motion into account simultaneously, the only hypothesis required is that the more distant stars are in general moving more slowly. This result differs from that of Adams and Strömberg, who did not take the ellipsoidal (or two-stream) motion into account. The author tabulates the elements of the ellipsoidal motion deduced from stars of small and of large proper motion separately, dividing each class into stars brighter than 3rd magnitude, stars from 3 to 5¼ mag., and stars from 5¼ to 6½ mag., taking into account the range of proper motion only in the case of stars of large P.M., where, he says, this range is large. After making some further criticism of the results of Adams and Strömberg, and again dividing up his data according to parallax, absolute magnitude, etc., he maintains that distance or region is the chief factor, but admits that as it seems necessary to classify the data according to so many different criteria, it is desirable that more extensive data should be employed. His hypothesis is stated in the following terms: The spectral condition of a star depends chiefly on its size and mass and the external conditions of density of cosmical matter and the relative velocities of star and matter. This matter is assumed to be more dense in the relatively distant regions in the direction of the galaxy. The cosmical matter acts as a resisting medium and slows down the higher velocities. [See also two next Abs.]. W. W. B.

1076. *Radial Velocity and Absolute Magnitude.* **W. S. Adams** and **G. Strömberg.** (Mt. Wilson Solar Observat., Contrib. No. 146. Astrophys. J. 47. pp. 189–192, April, 1918.)—This is by way of reply to Perrine's criticism [see preceding Abs.]. The authors point out that the chief difference between his view and theirs is that he interprets the increase of radial velocity with proper motion as mainly due to distance from the sun, while they attribute it to absolute magnitude. They also object that he has taken into account the large arithmetical range in proper motions greater than 0·1″ but ignored the very large geometrical range in those less than 1″. They emphasise the fact that dependence on distance from the sun involves attaching enormous importance in space to the actual position of the sun, which is not generally accepted. They take exception to his selection from their data instead of treating the whole at once. They conclude that he has misunderstood some of their tables, but that the whole matter is one of point of view and that the probabilities are in their favour.

W. W. B.

1077. *Cause Underlying Spectral Differences of the Stars.* **C. D. Perrine.** (Astrophys. J. 47. pp. 289–323, June, 1918.)—To test the hypothesis that the physical condition of a star is governed more by its "locality" than by the age of its evolution, the author examines a list of 745 double stars whose spectra have been classified at Harvard. He confines his attention to stars known to be physically connected and whose components differ by at least half a magnitude, and of such he finds 78 in the list. Where the fainter component is of the earlier type the pair is generally closer visually, so the next step is to see by examining the proper motions whether they are really closer, and the result appears to be that those in which the fainter component is of the earlier type are more distant from the sun. These stars show a preference for the galaxy. Further evidence from 19 stars found at Harvard to have composite spectra and from 62 stars in Campbell's Catalogue of Spectroscopic Binaries, suggests that the O and B stars and most of the A stars are distant. The conclusion is drawn from these and a few other stars that the relation observed is dependent on distance alone or coupled with low galactic latitude, but more extensive data are required.

The author's view is that if two stars of unequal mass are introduced into the near region the smaller one will progress more rapidly than the larger towards the later stage of evolution, while in the more distant galactic regions the smaller body would more rapidly become of an earlier type. He therefore considers that since location is so important the ordinary universal laws of gravitation, radiation, etc., are insufficient, and, rejecting as improbable local variations in these, gives as a probable and sufficient cause the presence of cosmical matter. The F, G, K, and M stars are evenly distributed so far as naked-eye stars are concerned, but the A stars and much more the B stars crowd into the galactic regions and avoid the rest of the sky; while nearly all the novæ, the class O stars, the planetary and gaseous nebulæ and the short-period variables also haunt the Milky Way. In the absence of parallax determinations recourse is had to proper motions to infer distance, but the classes just mentioned appear to be very distant. The B stars also appear to be more distant as we approach the early type. Pickering states that one in four of the bright stars belongs to class B, of the sixth magnitude only one out of twenty, and few if any below 7th or 8th magnitude. Nova Persei at maximum brightness was of the B type, but rapidly became of the usual "Nova" type with banded spectrum, approximating to an O or Wolf-Rayet star and then to a nebula. The author discusses the changes, attributing them to encounters with finely-divided solid cosmical matter. Again, activity evidenced by widening of spectral lines may be noted only in O, B, and A stars, which prefer the galactic regions. The Cepheid variables which show the same preference and are certainly very distant are brightest when approaching with maximum velocity, which the author explains to be due to the fact that the side facing the direction of motion necessarily meets more cosmical matter. Double stars moving among cosmical matter, will have their motion modified by the resisting medium and their period shortened until ultimately the companion may be driven down upon the primary. This, the author thinks, would not give rise to a nova, but possibly, a large gaseous nebula. His general evolutionary hypothesis is that stellar bodies encounter cosmic clouds, the resulting disturbance carrying them to a stage of evolution depending on mass and momentum, through B to O and on to nebula, moderate outbursts causing planetary nebulæ and the very violent ones producing irregular nebulæ. These two classes are discussed in some detail, and also the case of double stars of unequal masses, the smaller of which will, on account of its greater surface ratio, pick up mass relatively more quickly than the larger: and hence have its evolution accelerated as is consistent with the author's theory.

In an addendum, written after receipt of the list of parallaxes of 500 stars by Adams and Joy, the author deals with 24 of these stars which are of the physically connected class and have both spectra classified, finding full corroboration of his rule that when near the fainter component is of a later spectral type than the primary. He computes from the parallaxes that the limiting distance within which stars can be considered near for the purpose of his hypothesis is from 200 to 300 light-years. At this transitional distance the processes appear to take place much more slowly; a smaller change of spectral type being found for a given difference of magnitude than in either the nearer or more distant stars. He also finds on the average that the change of spectral type for a given difference of magnitude is less when the primary is of the earlier type than when it is of the later type.

W. W. B.

1078. *General Magnetic Field of the Sun: Apparent Variation of Strength with Atmospheric Level.* **G. E. Hale, F. H. Seares, A. van Maanen** and **F. Ellerman.** (Mt. Wilson Solar Observat., Contrib. No. 148. Astrophys. J. 47. pp. 206–254, May, 1918.)—In continuation and confirmation of a previous paper in which four lines were shown to have displacements attributable to the general field of the sun, the authors now find 26 new lines (chiefly of Fe and Cr, with a few of Ni, Ti, and V) with appreciable displacements. The measured displacements being very small in comparison with the width of some of the lines, there is great difficulty in the measurement, and some of the staff failed to obtain any results: Koch's registering microphotometer offers a promising method of avoiding this difficulty, an improved model being under process of construction in the workshops, with which it is hoped to determine systematic personal errors and also improve and simplify future measuring. Van Maanen's measures were made with a parallel plate micrometer, and some comparisons are given with the measures made in other ways by other observers. A full list of displacements is given, arranged according to solar latitude, an account being added of various precautions to minimise systematic errors of measurement. Most of the latitudes being between 20° and 70°, the work is shortened by grouping these in 10° bands N. and S. and ignoring the few outside these limits. Confirmation is obtained of the preliminary results, of the magnetic polarity previously deduced, with opposite sign in N. and S. hemispheres and practically equal mean value for 45° N. and S. latitude, showing that the magnetic axis and the rotation axis can only be inclined at a very small angle to each other; the whole being so nearly accordant with the behaviour of a uniformly magnetised sphere that no differences are found greater than can be explained by probable error of measures. Actually by means of the length of the series, which extended over an interval of 110 days, the changing longitude enables this inclination and the period of the rotation of the magnetic axis to be determined, the one coming out at $6{\cdot}2° \pm 0{\cdot}4°$, and the other $31{\cdot}79 \pm 0{\cdot}31$ days. In most of the cases the separation caused by a magnetic field of known strength is known from laboratory measurements, so that the field-strength can be inferred from the displacement of the solar lines; but there is the admitted difficulty of the measures, which is held to account for such discordances as a field of $18{\cdot}8\gamma$, where a previous determination gave 28γ. The field-strength varies with the intensity of the lines observed. For Fe and Cr a rapid decrease in field-strength accompanies increasing line-intensity, but for the three other elements there is too great uncertainty for more than a general agreement with this rule to be announced: St. John has, however, shown that increasing intensity means higher level in the solar atmosphere, so that the present results may be taken to show a variation of magnetic field with atmospheric level, with the reservation that a possible serious defect would appear in the argument if the personal errors of measurement varied with the intensity of the line measured. Detailed reasons are given for assuming that this defect, if it exists, has very little effect on the result. A comparison is made with Mitchell's flash-spectrum measures and the layer under observation proves to be a thin shell with a thickness of about 50 km. Other points dealt with in detail include the case of lines which show no displacement and the differences shown in sun-spots. It has been suggested that the general magnetic field is due to many local whirls, inferred to belong to spots or pores. Recent investigations at Mt. Wilson show an almost universal tendency for spots to occur in pairs, the chief members being of opposite polarity, and the preceding member being generally of different polarity in N. and S. hemispheres. Polarity seems also to be reversed at sun-spot minimum. Also the magnetic axes of spots are practically normal to the sun's surface and the strength of the field is roughly proportional to the area.

From these results the inference is drawn that the local-whirl hypothesis is not satisfactory, since the general field did not reverse at sun-spot minimum.
W. W. B.

1079. *Catathermic Phenomena at* 1000°C. **J. A. Le Bel.** (Comptes Rendus, 166. pp. 1047–1049, June 24, 1918.)—For the cosmic system to be in equilibrium, it is necessary that the heat lost by the stars should be conserved. Various hypotheses have been proposed; the most probable being that of Tissot, who assumes that stellar radiation may be transformed in space into centripetal rays which return the lost energy. This hypothesis was difficult to admit so long as no experimental analogy was to hand, and the author now produces data to this end. He shows that if in a material medium a flux of heat be caused from the centre towards the periphery, the energy may be returned and detected at the centre either by thermal means or electrically. This phenomena has been termed by the author "catathermic." Celestial space, therefore, which, according to Tickoff and Nordmann, possesses refractive power, is also, on Tissot's hypothesis, endowed with the faculty of generating the catathermic phenomena. An explanation is required, however, of the enormous difference between the heat returned per unit of volume to the sun and earth, and the author opines this to be involved in the nature of the respective pressure and temperature conditions. The variations of pressure which may be realised artificially are insignificant when compared to the differences between those of the sun and earth, but it is easy to produce an increase of 1000 deg. C., and, under these circumstances the catathermic phenomena are considerably modified. The novel experimental conditions are described at some length since the results obtained depended on the material of the detector, that of the containing walls, and on the thermal flow. The experimental catathermic phenomena appear to be due to a tension of the ether, rather than to rays as imagined by Tissot. If the same occurs in celestial space, then the energy returned to the sun will reach it in spite of its displacement, while the rectilinear centripetal rays will intersect its trajectory at a point where the sun has already passed by.
H. H. Ho.

1080. *Observation of the Apparent Focus of Auroral Streamers.* **C. C. Trowbridge.** (Phys. Rev. 11. pp. 483–484, June, 1918. Abstract of paper read before the Am. Phys. Soc., April, 1918.)—The widely seen aurora of Aug. 26, 1916, was observed by the writer from Prince Edward Island, Canada, and by J. Stebbins from near Frankfort, Michigan. Both observers found the focus from which the streamers radiated to be close to the magnetic zenith, or point to which the magnetic needle is directed. Other observations made on four occasions in 1917 by the writer point to the same conclusion, though the agreement in azimuth in individual observations was not always so close as that in altitude. The evidence suggests that the auroral rays lie parallel to the lines of magnetic force.
J. S. Di.

LIGHT.

1081. *Knife-edge Shadows for Testing Mirrors.* **R. W. Porter.** (Astrophys. J. 47. pp. 324–328, June, 1918.)—The author, finding it difficult to describe the so-called shadow caused by a knife-edge at the centre of curvature of a concave mirror, has, after many failures, succeeded in photographing the effect, and finds that the photograph reveals imperfections of the glass that have been unseen and unsuspected previously. The photograph, therefore, forms an invaluable final test of the figure of the mirror. The photograph being taken with the plate replacing the eye, no lens is required, so that no uncertainty is introduced from such a cause. Two plates of reproductions are given, and their appearance is described and explained in detail; the knife-edge being either near the centre of curvature or at the focus. W. W. B.

1082. *Correction of Optical Surfaces.* **A. A. Michelson.** (Nat. Acad. Sci., Proc. 4. pp. 210–212, July, 1918. Astrophys. J. 47. pp. 283–288, June, 1918.)—Describes a modification of Twyman's method for the correction of optical surfaces by means of an interferometer [see Abs. 356 (1918)], suitable for use in the case of lenses and mirrors of the sizes used for modern astronomical telescopes. A slit in the focus of the mirror or lens under test is illuminated by light from a Nernst filament, concentrated by means of a telescope objective and a total-reflection prism. The light returns immediately above the prism forming an image of the slit which is viewed through a microscope with a $\frac{1}{12}$-in. objective. A series of screens with two rectangular apertures are placed in succession in front of the lens or mirror to be tested, one of the apertures being central and the other at varying distances from the centre. The position of the central band of the resulting diffraction figure will remain constant if the adjustment is right and the mirror perfect. The error in light-waves will be half the observed error in fractions of the fringe width. The lens or mirror is rotated through the entire circumference at intervals of 45° or less, and the same operation repeated. The results are then plotted on the corresponding chart, which therefore gives the error in light-waves at every selected point of the surface. J. W. T. W.

1083. *Calculation of a Two-lens Objective.* **K. Yamada.** (Math. Phys. Soc., Tōkyō, Proc. 9. pp. 413–416, July, 1918.)—Gives a solution in terms of Abbe's invariant for the curvatures of the surfaces of a thin two-lens objective, free from chromatic aberration, spherical aberration, and coma for given object and image distances. The only variation from Harting's treatment for a telescope objective consists in the introduction of an additional term for the finite distance of the object. J. W. T. W.

1084. *Speed of Optical Signal in Absorptive Medium.* **A. Schidlof.** (Archives des Sciences, 46. pp. 34–37, July, 1918. Paper read before the Soc. de Physique de Genève.)—The speed of the front of an electromagnetic wave is here stated to be independent of the nature of the medium or path of the wave and equal to that (c) of light in a vacuum. The speed of the tail of the wave is, however, zero in an absorptive medium, since any disturbance once excited persists indefinitely but with an intensity which decreases rapidly with the time. Neither of these speeds can be identified with that of an optical signal, produced by allowing to pass or stopping an optical wave, which is propagated in the medium in question.

It is then shown that the speed sought may be expressed by—

$$U' = \frac{c}{n(1-k) - \mathrm{T}dn/d\mathrm{T} + \mathrm{T}d(nk)/d\mathrm{T}},$$

with the condition the denominator is greater than unity. In the above expression c is the speed of light *in vacuo*, n is the index of refraction of the medium, k its index of absorption, and T the period of the light. E. H. B.

1085. *Motions of Illuminated Particles.* (*Die Photophorese*). **F. Ehrenhaft.** (Ann. d. Physik, 56. 2. pp. 81–132, July 12, 1918.)—Experiments are here described in which particles of radius from (200 to 3) × 10^{-6} cm. pass through a beam of light of energy density 327 times as great as the sun's radiation on the earth's atmosphere, the wave-lengths of the experimental beam lying between (4 and 12) × 10^{-5} cm.

During such passages through the beam they may have motions *with* or *against* the direction of the light called respectively *light-positive* or *light-negative* motions. Further, the speeds of these *motions* (*Photophorese*) in the field of the beam of light increase with rarefaction of the surrounding gas.

Very elaborate details of the apparatus are given and photographic reproductions and tables for the effects observed. Sulphur spherules, silver, and gold were used for the particles, and nitrogen and argon for the surrounding gases. E. H. B.

1086. *Water-vapour Transparency to Low-temperature Radiation.* **F. E. Fowle.** (Smithsonian Misc. Coll. 68. [68 pp.], Oct., 1917.)—The main purpose of the research described was to determine the transparency of water-vapour, under atmospheric conditions, to radiation such as the warm earth sends towards space. The work deals chiefly with the transparency to radiation of wave-length greater than 2 μ, and its main interest lies in the numerous tables and diagrams of results. A brief abstract cannot be given. A. W.

1087. *Experimental Demonstration of Constant Speed of Light from Moving Source.* **Q. Majorana.** (Comptes Rendus, 167. pp. 71–73, July 8, 1918.)—Referring to his previous work on this subject [Abs. 50 (1918)] the author now describes further work which upholds the conclusion that the speed of light is not changed by the motion of its source along the direction of propagation. E. H. B.

1088. *Polarimetry.* (Bureau of Standards, Circ. No. 44. [2nd Edit. 192 pp.], Washington, 1918.)—A complete monograph dealing with present practice. L. H. W.

1089. *Natural Optical Activity of Isotropic Liquids.* **A. Landé.** (Ann. d. Physik, 56. 4. pp. 225–260, Aug. 2, 1918.)—The electronic theory of the natural optical rotation of crystals of isotropic and anisotropic liquids put forward by Born [Abs. 934 (1918)] rests upon a twofold extension of the ordinary dispersion theory, namely: I. Particles which are caused to oscillate by light-waves are coupled to each other by conservative forces (possessing a potential). II. The distance between the coupled particles is small but not to be neglected in comparison with the wave-length of the incident light, so that particles in different oscillation phases act on each other. In crystals, where every particle has a definite place in the space lattice, each particle is united to all the others by forces which diminish rapidly with the distance. In liquids, where every atom has its stable equilibrium position only within the molecule, while the orientation in space changes, a coupling is only accepted between the parts of one and the same molecule. The object of the present investigation is to explain explicitly the general oscillation magnitudes which occur in the generalised formula of Born in order to construct models of rotative molecules. In spite of the simplicity of the objective, there is a very complex dependence of the rotation on the spacial arrangement and the intramolecular forces which cannot be essentially simplified by approximations. The present paper only attempts, therefore, to show which properties of optical activity can be explained by the simplest mechanism and where more complicated hypotheses are requisite. Part I deals with the mathematical solution of the oscillation problem which includes consideration of the oscillation equations; a rigid solution of these; several special frequencies; approximation for weak coupling and isotropic union by two methods. Part II discusses particular models and includes Central coupling of asymmetric tetrahedra, Rotation coupling at anisotropic union, Central coupling at anisotropic union, and Application to asymmetric tetrahedra. H. H. Ho.

1090. *Magnetic Rotation of the Plane of Polarisation of Light in a Gas composed of Bohr Molecules.* **F. Pauer.** (Ann. d. Physik, 56. 4. pp. 261–320, Aug. 2, 1918. Extract of Dissertation, Munich.)—The calculation of dispersion by gases constituted in the sense of Bohr's molecular presentation has been given by Debye for hydrogen, and generally by Sommerfeld [see Abs. 520 (1918)]. Noteworthy results have been afforded by hydrogen, oxygen, and nitrogen. A further test of the views on molecular constitution and the fundamental quanta hypotheses relating thereto is afforded by investigating dispersion in the magnetic field. Scherrer has recently dealt with the rotation dispersion of hydrogen, and the present author now communicates a further investigation of the problem of the magnetic rotation of the polarisation plane by a gas composed of Bohr molecules with axial and equatorial symmetry and possessing a ring of electrons. Section I deals with the constitution of the symmetrical Bohr molecule made up of a ring of rotating electrons, with two nuclei symmetrically placed in the ring axis. Section 2 investigates the influence of the homogeneous magnetic field upon the motion of the electronic ring. Section 3 examines the free and forced oscillations when stationary motion is disturbed in a general way. Section 4 discusses external forces with respect to disturbance coordinates, and derives the electric movement of a system of electrons and nuclei. In Section 5 application is made of the general results on stationary motion and generalised forces to the case of light-waves passing through the Bohr molecule in a homogeneous magnetic field. The disturbance equations evolved are shown to be integrable by step-by-step approximation. In Section 6 the Lagrange function for the electronic ring of a Bohr molecule is derived, its coefficients calculated and its properties examined. In Section 7 the disturbance equations are applied to the special case where no disturbing electrical forces are present. Section 8 deals with the solution of the disturbance equations for the general case of the action of a homogeneous magnetic field and electric forces upon the molecule. In Section 9 the resultant electric moment of the incident light-waves is derived. Section 10 examines the connection between electric moment, refractive index and magnetic rotation of the polarisation plane. In Section 11 the Verdet constants are calculated from the refractive indices for two circularly polarised light-waves rotating in opposite senses. Section 12 deals with changes in the original quanta representation and the influence of these on the Verdet constant.

The main results are as follows :—The calculations of Scherrer for the hydrogen molecule have been rectified and generalised ; the quanta hypothesis utilised, which agreed with the adiabatic hypothesis, has been confirmed and extended. The results have also been applied to the case of the paramagnetic installation of molecules in the magnetic field. The final formula for the Verdet constant contains only universal quantities, and is formed, like the ordinary dispersion formula, of Sommerfeld's model functions f and ϕ.

H. H. Ho.

1091. *Perturbations in the Series Lines of Band Spectra.* **T. Heurlinger.** (Phys. Zeits. 19. pp. 316–318, July 15, 1918.)—This paper first discusses in general the subject of the irregularities or perturbations in the series lines of band spectra, with reference to Deslandres' laws [Abs. 237 (1914)]. Tables and diagrams are then given dealing with lines of the so-called cyanogen band and supporting the views advanced in the first part of the paper.

A. W.

1092. *Nitrogen Spectrum.* **O. Hardtke.** (Ann. d. Physik, 56. 5. pp. 363–382, Aug. 22, 1918.)—Describes research on the conditions required for the emission of the spectrum of nitrogen. Measurements were also made of the wave-lengths of lines in the arc spectrum of nitrogen. A table is given including the wave-lengths of 38 new lines in the region from λ5832 to λ4012. Diagrams are also given showing the variations of intensity distribution in the spectrum of N_2^+ moleculions under different conditions of excitation. The occurrence of the N_2^+ bands in the nitrogen canal-ray spectrum was definitely established, and it was also shown that the N bands (so-called cyanogen bands) occur in a Geissler tube at low pressures. The experiments lead to the conclusion that the three positive band groups of nitrogen do not belong to the element nitrogen, but to one of its compounds with oxygen.

A. W.

1093. *Stark-effect in Helium and Hydrogen.* **T. Takamine** and **N. Kokubu.** (Math. Phys. Soc., Tōkyō, Proc. 9. pp. 394–404, July, 1918.)—A continuation of previous work [see Abs. 955 (1917), 839, and 840 (1918)]. Lo Surdo's method was again used. The results of the present investigation were as follows :—In the case of H_γ the central line in the perpendicular component was found to be shifted about 1 Å.U. towards the red side in a field of 130,000 volts/cm. For helium 18 lines were examined, 7 of which have not previously been dealt with by other investigators, so that results are now available for 26 lines. The lines λλ4438, 4121, and 3965, which had hitherto been thought to be merely shifted by an electric field, were found to be resolved into a number of components, all being shifted in the same direction. A striking similarity was noted in the Stark-effect for the helium line λ4388 and for the hydrogen line H . In both cases the central line in the perpendicular component is the strongest of all the components, and it is shifted towards the red as the field-strength is increased. The only difference between the helium and hydrogen lines is that this central *s*-component shows a discontinuity at its starting-point in the case of helium. This similarity in the Stark-effect for corresponding lines of helium and hydrogen appears to suggest some connection between the mechanism of emission from the atoms of these two elements. The advantages of using an echelon grating for examining the Stark-effect are discussed. A. W.

1094. *Stark-effect for Argon Lines.* **T. Takamine** and **N. Kokubu.** (Math. Phys. Soc., Tōkyō, Proc. 9. pp. 405–408, July, 1918.)—Using the same experimental arrangements as in previous work on helium and hydrogen [see preceding Abs.] the Stark-effect for 16 lines in the spectrum of argon was investigated. The effect on argon lines was found to be extremely small compared with that on helium and neon lines, and it was only after repeated experiments, using a very strong field, that a group of lines in the violet region were found to be displaced towards the red. The lines observed lie between the limits λ4933 and λ4046. The greatest field strength employed was about 170,000 volts/cm. It is remarkable that almost all the affected lines belong to the "red spectrum" of argon. Thus, so far as the present work is concerned, the so-called "arc" lines seem to be more easily affected by an electric field than the "spark" lines. This is in agreement with previous results obtained for the Stark-effect on the lines of He, Ca, and Mg. Beside the argon lines, a mercury line λ4339 was found to be displaced about 0·7 Å.U. for the *p*-component, and 0·5 Å.U. for the *s*-component, towards the red in a field of 53,000 volts/cm. A. W.

1095. *Luminescence of the Uranyl Salts under Kathode-ray Excitation.* **[Miss] F. G. Wick** and **[Miss] L. S. McDowell.** (Phys. Rev. 11. pp. 421–429, June, 1918.)—The position of the absorption bands of the uranyl salts is very nearly coincident with that of the fluorescence bands [Abs. 527 and 779 (1918)], and it seemed probable that the difference observed was due to the fact that a portion of each fluorescence band under light excitation was cut off by absorption so that the observed position of the crest differed slightly from the true position. In order to determine whether any such effect occurs, a comparative study was undertaken of the fluorescence of the uranyl salts under excitation by ordinary light and by kathode rays, since in the latter case the effect is only upon the surface and there is no absorption to shift the apparent position of the maximum. In the course of the investigation there was discovered a long-period phosphorescence of the uranyl salts under excitation by kathode rays, at liquid-air temperature. This phosphorescence could only be produced by kathode rays after prolonged excitation, and its spectrum was found to be identical with the fluorescence spectrum. The decay curve is of the type usual to phosphorescence of long duration, in which the second process is less rapid than the first. As regards the fluorescence bands, it had been found in the earlier work that the frequency interval in the violet end of the spectrum was less than the other intervals of the series, ordinary light being used for excitation. Under kathode-ray excitation, however, the frequency interval at the violet end is practically equal to the other intervals of the series, and the experiments show that the inequality in the interval and the change in the appearance of the violet band under excitation by ordinary light are due to absorption, as had been anticipated. A. W.

1096. *Limit of the Continuous X-ray Spectrum.* **A. Muller.** (Archives des Sciences, 46. pp. 63–73, Aug., 1918.)—According to the theory of quanta, there is a lower limit to the wave-length which may exist in the continuous spectrum of the X-rays from a radiating tube. Since the experimental evidence supporting this view is not very great, the author has considered it advisable to publish the present paper, which describes a new method by which the theory is verified.

The relation due to Einstein, $eV = h\nu$, has been verified with an accuracy of several per cent. in the case of continuous X-ray spectra between 14 and 28 kilovolts. The experiments have demonstrated that the results can be obtained by relatively simple methods. The mean value of h calculated from the photographic measurements is given as $h = 6{\cdot}58 \times 10^{-27} \pm 0{\cdot}07 \times 10^{-27}$ erg. sec. with a relative error of approximately 2 %. [In this calculation Millikan's value of $e = 4{\cdot}774 \times 10^{-10}$ e.s. unit is assumed.] A. B. W.

1097. *Characteristic X-ray Emission as a Function of Applied Voltage.* **B. Davis.** (Phys. Rev. 11. pp. 433–444, June, 1918.)—The author has examined this question mathematically, basing his calculations on the following well-established facts :—(*a*) The characteristic line emission is zero for all voltages less than a critical voltage V_0. (*b*) The voltage V_0 at which the characteristic radiation is produced is that corresponding by the quantum relation $V_0 e = h\nu$, to a frequency slightly greater than that of the K_β radiation of the element. (*c*) At voltages equal to or greater than V_0 both the α and β lines of the K radiation are emitted. These two lines increase rapidly in intensity with the voltage, their ratios remaining approximately constant. (*d*) X-radiation is not only emitted from the surface atoms of the target, but also from the atoms beneath the surface when they are impacted by the electrons of the kathode stream. (*e*) The electrons penetrate a short distance into the surface of the target, but their velocity diminishes rapidly with depth of penetration. (*f*) The emitted X-rays are absorbed on their passage through matter. This absorption depends on the thickness and nature of the material traversed.

The only hypothesis adopted is directly in keeping with the Bohr theory of the atom.

The question of X-ray emission from these films is also examined mathematically. A. B. W.

1098. *Grating Space of Calcite, and X-ray Spectrum of Gallium.* **A. H. Compton.** (Phys. Rev. 11. pp. 430–432, June, 1918.)—Uhler and Cooksey [Abs. 267 (1918)] have described a method of measuring the angle of reflection of X-ray spectrum lines which seems to be remarkably free from systematic errors, and capable of high precision. They applied their method to the determination of the angle of reflection of the characteristic K lines of gallium from a crystal of calcite. In calculating the wave-length of these rays they obtained the grating space of calcite by comparing it experimentally with the grating space of rock-salt, which can be determined in terms of the known crystal structure. In making this comparison, however, they determined the angles of reflection from rock-salt by an "old" method which, as they point out, is liable to introduce appreciable errors. Their determination of the grating space of calcite, and hence also of the wave-length of the characteristic X-rays from gallium, is therefore no more accurate than the measurements by the "old" method which they criticise.

The author of the present paper now points out that the grating space in the case of calcite may be calculated from the known crystal structure as well as in the case of rock-salt. The formula to be used is given by W. L. Bragg [Abs. 876 (1914)] and the author [Abs. 1043 (1916)] as

$$d_1 = \left(\frac{M_1}{2\rho_1 N \phi(\beta_1)}\right)^{1/3},$$

where M_1 is the molecular weight of $CaCO_3$, ρ_1 the density of the calcite crystal, N the number of molecules per gm.-molecule, and $\phi(\beta_1)$ is the volume of a rhombohedron the distance between whose opposite faces is unity, and the angle between whose edges is β_1. This function for calcite is equal to 1·0963.

On the above basis the author corrects Uhler and Cooksey's values for the wave-lengths of the characteristic X-rays from gallium. **H. S. Uhler.** (*Ibid.* 12. pp. 39–46, July, 1918.)—Uhler replies to Compton's criticism. A. B. W.

RADIO-ACTIVITY.

1099. *Radium in Warfare.* **C. H. Viol** and **G. D. Kammer.** (Am. Electrochem. Soc., Trans. 32. pp. 381–388; Disc., 388–390, 1917.)—Describes briefly the sources of radium and the process of its extraction from the crude carnotite, of which 300 to 500 tons must be treated to yield 1 gm. of radium element. The therapeutic uses of radium are briefly mentioned. The composition and characteristics of radium luminous compound are described as well as the method of comparing the relative degrees of luminescence exhibited by two samples of zinc sulphide. The decay of the luminescence is mentioned, and the results obtained at the National Physical Laboratory are summarised [see Abs. 933 (1917)]. In the *discussion*, **N. E. Dorsey** stated that the observations at the Bureau of Standards lead to the belief that the decay curve of radium luminous compound for at least the first 300 days is of the hyperbolic form $B = l/(a + bt)$, where l, a, and b are constants, a varying approximately inversely as the Ra content of the material. J. W. T. W.

1100. *Range of α-Rays on the Sensitive Layer of Photographic Plates.* **E. Mühlestein.** (Archives des Sciences, 46. pp. 48–49, July, 1918.)—The paper describes a study of the haloes produced when a speck of radio-active matter is placed on a photographic plate. Similar experiments were made by Ikeuti [Abs. 1047 (1916)] in which the ranges of α-particles from various radio-active substances were measured microscopically.

The author now gives the following values for the ranges of α-particles in photographic films:—

From RaC	50·7 μ
„ Polonium	26 μ

Generally speaking, the range is practically independent of the type of photographic plate. Thus only ½ % difference in range was observed between the plates "Sigurd-Foto" and "Ilford Process." A. B. W.

1101. *Isotopic Lead.* **F. W. Clarke.** (Nat. Acad. Sci., Proc. 4. pp. 181–188, June, 1918.)—Notes on the numerous determinations of the atomic weight of lead obtained from different minerals—ordinary lead, thorium lead, and uranium lead.

The author considers that the uranium-lead ratio for ratio-active minerals is not applicable to the determination of the age of minerals, since only a part of the lead in uranium ores is of radio-active origin. An attempt is made by the author to define the fundamental difference between normal lead and isotopic lead. He assumes that the former is a product of an orderly evolution of the chemical elements, and the latter a product of their decay. He asserted 45 years ago (Popular Science Monthly, Jan., 1873) that an evolution of the elements had actually occurred—as indicated by the progressive chemical complexity of the heavenly bodies, from the chemically simple gaseous nebulæ, through the hotter stars and the sun, to the finished planets like our earth.

Further evidence, particularly radio-active, is now brought forward to support this hypothesis. A. B. W.

1102. *Some Properties of Metals under the Influence of α-Rays.* **A. G. McGougan.** (Phys. Rev. 12. pp. 122–129, Aug., 1918.)—The paper describes an experimental study of the production of δ-rays when metallic surfaces are bombarded by α-rays. The author summarises his results as follows:—

(1) The δ-ray current from a metal under bombardment by α-rays in a high vacuum is reduced by scraping the surface of the metal with a steel scraper while the vacuum is maintained. The reduction effected in these experiments varied from 6 % to 37 % for lead.

(2) The reduction of δ-ray emission is not permanent; a recovery was observed a short time after scraping and a complete restoration took place in one day.

(3) The δ-ray emission from a mercury surface is not affected by overflowing the surface. The emission from mercury is practically the same as from other metals, all the curves having the same shape.

(4) The evidence presented in these experiments supports the view that the δ-ray effect in metals is due to a gas film on the surface. In the case of mercury it seems more likely that this film is formed from molecules of gas contained within the liquid. A. B. W.

1103. *Magnetic Deflection of β-Rays.* **[Miss] N. C. B. Allen.** (Roy. Soc. Victoria, Proc. 30. 2. pp. 142–144, March, 1918.)—The negative electron, when it possesses a velocity v cm./sec., is deflected by a uniform magnetic field, H gauss, at right angles to its direction of motion, into a circular path of radius R cm. such that $RH = vm/e$, m gm. being the transverse mass of the negative electron for a velocity v cm./sec. $m = m_0\phi(\beta)$, where $\beta = v/\nu$, v cm./sec. being the velocity of light. In experiments on kathode and β-rays it is frequently necessary to calculate the velocity of rays when RH is known. Since e/m_0 is now well known, and Lorentz's theory that $m = m_0(1 - \beta^2)^{-1/2}$ has been confirmed by Bucherer, it is convenient to tabulate v with RH as argument.

Using a mean value $1{\cdot}763 \times 10^7$ for e/m_0 and a value $2{\cdot}9986 \times 10^{10}$ cm.-sec. for the velocity of light, the author tabulates "v" with respect to "RH."

A. B. W.

1104. *Extraction of Radium from American Pitchblende Ores by Chlorination.* **[Mrs.] R. Cable and H. Schlundt.** (Met. and Chem. Eng. 18. pp. 460–462, May 1, 1918. Chem. News, 117. pp. 244–246, July 19, 1918.)—The experimental results presented in this paper were obtained by a new method of extracting radium by direct chlorination of the ore. This method has particular application to pitchblende ores in which the uraninite occurs intimately associated with iron pyrites. Good results have been obtained.

A few chlorination experiments with carnotite ore did not give results of promise for a method of extracting radium. A. B. W.

HEAT.

1105. *Thermal Expansion of Regular Crystallising Solid Bodies.* **E. Grüneisen.** (Ann. d. Physik, 55. 5. pp. 371–386, June 4, 1918.)—In the author's previous communication on the theory of the solid state [Abs. 268 (1918)] he derived an equation for monatomic elements which expressed their thermal expansion, namely: $\frac{v_T - v_0}{v_0} = \frac{E}{\phi_0\left(1 - k\frac{E}{\phi_0}\right)}$, where E is the molecular oscillation energy per volume v, while ϕ_0 and k are constants. This equation was found to be in fair agreement with the experimental results for copper, platinum, and the diamond. The theoretical basis for this equation follows from Nernst's theory of heat applied to all solid bodies whose molecular heat can be expressed by a single function of v/T. A correction term has to be introduced which depends on the fact that the third differential of the inner potential energy with respect to the volume does not vanish, and, in consequence, involves special hypotheses. The author now returns to the subject on account of a recent series of measurements by Valentiner and Wallot on the thermal expansions of Pt, Ir, Rh, Si, fluorspar, and pyrites, which are of special value inasmuch as the expansion has been measured by the interference method between a series of short temperature ranges thereby permitting a true expansion coefficient for the average temperature to be obtained. These data are particularly suitable for testing the theory, and the present paper reopens the subject. Silicon is seen to be a complete exception, since it possesses a negative expansion coefficient. The author differs in his conclusions with respect to the other five substances, Pt, Ir, Rh, CaF_2, and FeS_2, from Valentiner and Wallot who have sought to prove the expansion coefficient proportional to the Nernst-Lindemann function for c_v. They have succeeded in this quest only with values of ν, which are considerably greater than those obtained in other ways. The author shows that an extrapolation of the formula must lead to considerable errors, and points out two reasons why his conclusions differ from those of Valentiner and Wallot, viz., in the use of the Nernst-Lindemann, instead of the Debye function, which gives strongly divergent values for CaF_2 and FeS_2, and in the neglect of the above correction term. A section is devoted to a discussion of the method employed, following which comes an examination of the results for monatomic elements. Six tables of results for the diamond, Pt, Ir, Cu, Al, and Au, accompany the section. Regular crystallisable bodies, which are polyatomic, are then dealt with in the cases of fluorspar and pyrites.

The general conclusion drawn is that not only monatomic solid elements, but also regular crystalline bodies, whose molecular heats are expressed by the Debye function with a single limiting frequency, follow the law of thermal expansion as expressed by the above equation. The explanation of certain deviations, especially in the case of the diamond, must await further experiment. For higher temperatures it is sometimes necessary to increase the constant k above its theoretical value, thereby making the equation into an empirical interpolation formula. At low temperatures the formula holds good.
H. H. Ho.

1106. *Preferential Catalytic Combustion of the Gases of Mixtures.* **W. D. Bancroft.** (Am. Electrochem. Soc., Trans. 32. pp. 465–474, 1917.)—A discussion of the question which of the two combustible gases of a mixture will burn more readily in the presence of oxygen and of a catalyst (platinum, copper oxide, borosilicate glass, chamotte). The author has not made any new experiments and does not follow up the argument he starts from, namely, that catalysts like platinum black saturated with H, CO, CH_4, O, etc., may be considered as gas electrodes, and that it should be possible to calculate the oxidisability from the electromotive force, provided the e.m.f. calculated from the free energy of H and O be really the true e.m.f. of the H-O cell.

From the experiments of various investigators it appears that at low temperatures the nature of the catalyst may determine which gas will burn the more readily; at very high temperatures the specific effect of the catalyst will become negligible because the equilibrium then will be that of the gas phase and not that of the catalyst. Hydrogen burns more readily than methane or ethylene in presence of Pt or Pd (Henry, Hempel); in presence of copper oxide all hydrogen burns at 250°, while methane is not attacked (Jäger); in the presence of chamotte at 500° hydrogen likewise burns much more readily than methane; but this preferential combustion of hydrogen is by no means general. In borosilicate glass bulbs at 300° or 400° methane, ethane, ethylene, acetylene are oxidised much more readily than H and CO (Bone); when mixtures are exploded by the electric spark, methane also burns more readily than either H or CO; which of these two gases will be the more oxidisable depends on the conditions. Charcoal oxidises ethylene at ordinary temperature, but does not cause H and O to combine (Calvert). Since relatively more methane is burned in explosions in large bombs than in small bombs (Bone), it seems probable that hydrogen is less oxidisable than methane at high temperatures in the absence of any catalysts. H. B.

1107. *On the Thermodynamics of Springs.* **H. Bock.** (Zeits. Instrumentenk. 38. pp. 109–115, July, 1918.)—The thermal processes which ensue during the extension of elastic bodies have long been known, but although of outstanding significance for engineers, yet the data have been seldom employed by them, probably owing to the form in which they have usually been expressed. The author now attempts by means of an analogy with the p-v diagram to give a simple process whose application to the theory of springs leads to the possibility of expressing numerically the elastic after-effect. It is shown that perfectly elastic bodies must be attended by such after-effects—a fact of considerable importance for fine springs such as chronometer spirals. The various limitations assumed are first given, and then the equation of state of a long bar is derived corresponding to that for a gas. The σ-l diagram is next plotted, where l is the length and σ the tension along this direction. Following this comes a discussion of the internal energy of the bar, together with the determination of c_l (the specific heat at constant length corresponding to that of constant volume in the gas equation). The adiabatics of the bar is next examined, and the expression for the entropy obtained. The theoretical results are then applied to determine the energy loss when the bar is made into a spring, and the special case of energy loss in the watch-spring concludes the paper. H. H. Ho.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

1108. *Atoms and Electromagnetic Theory.* **A. C. Crehore.** (Am. I. E. E., Proc. 37. pp. 283-315, April, 1918. Electrician, 81. pp. 350-351, Aug. 23; 372-373, Aug. 30; 392-393, Sept. 6, and pp. 412-414, Sept. 13, 1918.)—The paper is an interesting summary of the results of the author's researches in atomic theory founded upon his solution in its most general form of the problem of finding the force exerted by an electron describing uniformly a circular orbit upon an electron describing also uniformly a circular orbit. The application of the result to Bohr's theory profoundly modifies it, involving the conclusions that the magnitude of the radius of a ring containing two electrons is 10^{-10} instead of 10^{-8}; that there is no change in kinetic energy from orbit to orbit, the energy change being of the nature of potential energy, the work done in separating the electrons against the radial forces—leading to a very different series of radii from those of Bohr; and that the assumption of equal angular moment of momentum for each and every electron in all atoms is untenable. And the theory thus modified is found to agree still more closely with observation than in its original form. It gives, moreover, a valid reason why there may be a great increase in the velocity when electrons are ejected from atoms, and accounts, in the form of a very simple formula, for the voltages required to ionise and start radiation in gases having single rings of electrons, such as hydrogen and helium. Calculation of the average force between two distant electrons, one in each of two atoms of any gas, liquid, or solid, crystals excepted, leads directly to an attraction inversely as the square of the distance. And the author has shown further that in the case of crystals the attraction is independent of the orientation of the axes, and therefore of the form which would be required to account for gravitation—but the amount is 10^{31} too great. Hence one of the two assumptions, that the electronic orbits are actually or approximately circles, uniformly described; or that the modern Lorentz electromagnetic equations apply, must be untenable. The author's view is that some very important factor has been omitted from the Lorentz theory. Now the force equation is not symmetrical in respect to the two electrons. But by introducing the square of the velocity of the first electron as well as that of the second, into the equation, and also the mass at small velocities of the electron, a symmetrical expression is obtained for the force, and the amount of the attraction is brought into surprisingly close agreement with that corresponding to the law of gravitation. The change in the electromagnetic equations would relate more particularly to the inverse square of the distance terms, and would probably not seriously affect most applications of the theory.

G. W. DE T.

1109. *The Electromagnetic Mass of Crystals.* **M. Born.** (Preuss. Akad. Wiss. Berlin, Ber. 34. pp. 712-718, 1918.)—One of the most important results of the theory of relativity is the hypothesis of the inertia of energy, whereby the inert mass M of a system of energy-content E is expressed by the formula $M = E/c^2$, where c is the velocity of light. The hypothesis arose from experiments devised to explain the inertia of electrons on purely electromagnetic grounds. Afterwards an extension to energy inertia was discovered in space radiation. At present the latter hypothesis appears to be a general consequence of the theory of relativity, although further examples by which the inertia possibility of energy can be calculated explicitly from the mechanism of the system have not yet been forthcoming. The author now attempts to show that the inertia of the electromagnetic energy can be derived quite generally from all crystals from the lattice theory. The energy of a crystal is composed of the intra-atomistic energy and that of the forces which contain the atoms in the lattice configuration. The former, which by far outweighs the latter, has, from the standpoint of the lattice theory to be treated simply with the given atoms, and to it corresponds a constant mass. The second part of the energy may be calculated when the active molecular forces between the atoms (and electrons) are given. The latter, however, are not as yet known, although the electromagnetic effects which proceed from the charged atoms and electrons are certainly to be included with the molecular forces. These electromagnetic forces are now ascertainable, and it should therefore be possible to calculate from them the corresponding part of the mass density. For the necessary mathematical methods the reader is referred to the author's book *Dynamik der Kristallgitter*, where the equations of motion of the particle of a crystal lattice are developed under the assumption that, besides conservative timeless quasi-elastic forces, there are electromagnetic forces spreading with the velocity of light from one particle to another. The solution of the equations of motion, however, has only been completely carried out for the case of very rapid vibrations corresponding to the propagation of light-waves. The slower vibrating elastic waves were not then worked out, because the author believed nothing new would be gained thereby. He has now noticed that an insignificant difference between the formulæ includes the phenomenon of the inertia of electric energy. The present paper, therefore, contains the equations of motion and their solution for slow vibrations. A further example is thereby obtained of the inertia of energy. H. H. Ho.

1110. *The First and Second Electronic Rings of the Atom.* **J. Kroo.** (Phys. Zeits. 19. pp. 307–311, July 15, 1918.)—The oldest model conception of high-frequency spectra on the quanta theory is that of a Bohr's orbit in which several electrons revolve; and that the mechanism of radiation consists in a transition of electrons from an outer to an inner ring. From this standpoint, Moseley obtained an approximate representation for the principal line of the K series in which a transition takes place of 4 electrons from the di-quanta to a mono-quanta ring. Vegard later came to the conclusion that the K_{a_1} series was produced by the passage of a single electron from the di- to the mono-quanta orbit. Next Debye has shown [Abs. 1086 (1917)] that the assumption of 3 electrons in the normal state in a mono-quanta Bohr orbit leads equally as well to a K_{a_1} series as to the empirical formula evolved by Sommerfeld from his profound researches into the structure of the Röntgen spectra. The present author now attempts to generalise these theories, and, for this purpose, assumes that all Bohr orbits are charged with electrons. The main problem is therefore to find the number of electrons per ring. Only the particular case of the K_{a_1} series is dealt with in this paper, and its origin is ascribed to the passage of an electron between the mono- and di-quanta orbits. Section 1 deals with the calculation of the frequency. Section 2 considers the mass changes which may ensue. Section 3 contains a comparison of theoretical and observed data.

The conclusion is drawn that for the K_{a_1} series the mono-quanta orbit contains 3 electrons, while the di-quanta ring possesses 8 electrons.

H. H. Ho.

1111. *Electromagnetic Inertia of the Lorentz Electron.* **G. A. Schott.** (Roy Soc., Proc. 94. pp. 422–436, June 1, 1918.)—The paper consists of a detailed analytical investigation into the origin of the discrepancies in the values of the longitudinal and transverse masses of a moving electron as determined by the mass formulæ of Lorentz and in accordance with the principle of relativity, on the one hand, and those obtained by G. W. Walker [Abs. 1363 (1917)], on the other. The value of the longitudinal mass obtained by Walker is found to be correct, according to his assumptions, and also the value of the transverse mass, subject to a correction due to an error in sign occurring in Walker's calculation, as tested by the method developed by Schott in *Electromagnetic Radiation.* In this method the usual retarded potentials due to an element of charge moving in any assigned manner are developed in series, of which the first terms are the potentials of the elements due to uniform motion with the velocity at the instant considered, and the other terms are derived from them by definitely assigned operations, and involve the accelerations of various orders. The electric, magnetic, and mechanical forces on a second element of charge are derived by the usual operations, and the resultant mechanical force on the electron is obtained by a double integration over all the pairs of elements of charge in the form of a series in ascending powers of a length a, measuring the linear dimensions of the electron—the radius for the Abraham electron, the transverse radius for that of Lorentz. The first two terms of this series for the internal electromagnetic force F on the electron are of the form $\mathbf{F} = -d\mathbf{G}/dt + \mathbf{K}$. The first, and principal, term is the only term found in the ordinary energy method, employed by Lorentz, which involves the quasi-stationary assumption. **G** may be identified with the electromagnetic momentum, is of order a^{-1}, and depends only on the configuration of the electron, on the relative motion of its parts, and on the velocity of its centre, all at this instant considered. **K** represents the reaction due to radiation, and depends only on the velocity, acceleration, and acceleration of second order, of the electron. Even in the case of an electron moving in an orbit of atomic dimensions, the effect of **K** would be unimportant, and in all practical cases the author considers that the effect of higher terms would be quite negligible, and according to his results the error made in assuming quasi-stationary motion arises from neglecting **K** and higher terms. And this series depends only on three assumptions—namely, the retarded potentials of a point charge, according to Liénard and Wiechert; the usual expression for the mechanical force on a moving electric charge, together with the usual rule for composition of forces; and the convergence of the expansions used for the potentials and electric, magnetic, and mechanical forces. The third assumption does not appear capable of proof for the most general type of motion, but the author has shown [Abs. 435 (1908)] them to be convergent in certain cases, and almost certainly for a uniform longitudinal acceleration, in all cases where the acceleration is not too great, and the speed of the electron not too close to that of light. With this proviso, the author's expression for the electromagnetic momentum is applicable to any electron, whatever its constitution, form, state of strain or internal motion, and motion as a whole may be, provided the relative velocities of its parts are small enough. Now the author's results agree with those of Lorentz as far as the first term is concerned, but both differ from those of Walker, so it would appear that the discrepancies must be attributed, not, as Walker suggests, to the quasi-stationary assumptions, or the energy method employed by Lorentz, neither being used by the author, but to the differences in the fundamental assumptions as to the constitution of the electron and the character of its motion. The two electron models should be regarded as essentially distinct, and the relative merits of the two sets of mass formulæ assessed in the light of their agreement with experiment and their adaptability to the purposes of theory. The Lorentz model has the advantage over Walker's, and also over Abraham's, of leading to far simpler formulæ, and until methods sufficiently delicate to differentiate between them are found, the relative merits of the respective mass formulæ can hardly be assessed otherwise than in accordance with their relative simplicity and their adaptability to the purposes of theory.

G. W. DE T.

1112. *Electromagnetic Field of a Moving Electric Doublet.* **K. Tamaki.** (Kyōto Coll. Sci., Mem. 2. pp. 293–296, Oct., 1917.)—The author shows how the field due to an electric doublet moving in any direction at constant speed may be easily obtained by aid of the generalised Lorentz-Einstein transformation equations which he had derived in an earlier paper [Abs. 1508 (1910)].

G. W. DE T.

1113. *Point-Potential Expansions.* **A. W. Conway.** (Roy. Soc., Proc. 94. pp. 436–452, June 1, 1918.)—By point-potential is meant the scalar or vector potential of a point-charge moving in any manner with speed less than that of light. Its general form is $f(\tau)/r(1 - c^{-1}\partial r/\partial \tau)$, where r is the distance of the point-charge from the field-point at time τ, c the speed of light, and $f(\tau)$ an arbitrary function of τ, τ being given by the equation $c(t-\tau)=r$. After references to the extensive literature of the subject, the author develops a new type of expansion of great generality, using the method of complex integration which he employed in an earlier paper [Lond. Math. Soc., Proc. Ser. 2. Vol. 1]. Taking axes with origin O and having fixed directions in space, E the position of the point-charge, and P that of the field-point, the point-potential is expounded in a series $\Sigma \Upsilon_n U_n$, where Υ^n is a spherical harmonic of the angles made by OP with the axes, and U_n is a function depending on the positions of O and E and the distance OP. It is thus analogous to the ordinary harmonic expansions of r^{-1}, or of the more general potential $e^{-kr}r^{-1}$. But it is of more general type than the latter since the origin may be in motion in any manner. The convergence of the series is investigated and methods of calculation are obtained. Examples are given, including the formal solution of the problem of the motion of a point-charge outside a fixed spherical conductor, and the connection with the Lagrangian expansion is shown. G. W. DE T.

1114. *Approximation to Electric Field of a Bent Antenna.* **W. Nakayama.** (Kyōto Coll. Sci., Mem. 2. pp. 297–313, Oct., 1917.)—The bent antenna is supposed to consist of two linear oscillators, one vertical and the other horizontal, forming an inverted L. Assuming the horizontal arm to be double the length of the vertical, and that oscillation currents of the same phase are excited in each part, and considering each linear oscillator as a combination of Hertzian doublets in series, the known series for the horizontal and vertical electric force components dY and dZ due to an elementary Hertzian doublet oscillator at a distance r from its centre gives, very simply, corresponding series for a linear oscillator. By integration, which is worked out at length, Y and Z are obtained for the linear oscillator, and hence, by the method of images, Y and Z for the inverted L. G. W. DE T.

1115. *Investigation of Lightning-flashes temporarily following One Another and Associated Together.* **B. Walter.** (Phys. Zeits. 19. pp. 273–279, July 1, 1918.)—A previous communication on this subject was treated of in Abs. 656 (1913). The author here describes a method of ascertaining the components of the main and subsidiary flashes which the eye cannot observe, by using a fixed and a moving camera. This enables him to record the oscillations and to calculate the time intervals between them. Thus a discharge observed by the author and lasting 0·556 sec. is shown to have components individually of durations 0·132, 0·071, 0·035, 0·020, 0·233, 0·054, and 0·011 sec. Illustrations are given with figures and tables. E. O. W.

DISCHARGE AND OSCILLATIONS.

1116. *Effect of a Magnetic Field upon Kathode Rays.* **L. T. More** and **L. M. Alexander.** (Phys. Rev. 12. pp. 1–12, July, 1918.)—The changes produced in the appearance of the discharge from the kathode of a Geissler tube when it is subjected to a strong magnetic field are very marked. It was generally supposed that the action of a magnetic field was to change the paths of the negative particles of the kathode rays into helices. But Righi, after an elaborate series of experiments in which he caused the magnetised kathode ray tō issue into a large tube, found such remarkable secondary effects that he abandoned the abōve idea as inadequate and proposed an entirely new hypothesis. He assumed that the magnetic field creates and makes stable a stream of electrically neutral doublets, each of which consists of an electron rotating in the same direction about a heavy, and positively electrified, gas ion, and that the magnetic field further exercises on the doublets a directive force to drive them to places of lower magnetic potential. When this stream, which he calls a "magnetic ray" has moved a critical distance from the kathode, the magnetic field is no longer strong enough to overcome the centrifugal force of the rotating electrons and the doublets break up. The secondary effects in the large tube he ascribes to the actions of their disassociated constituents. Experiments made by More and Mauchly and Riemen, on the other hand, gave decided evidence against any such doublets being formed. In those of the experiments on which the greater dependence can be placed, a hot-lime, or Wehnelt kathode was used, and it was shown that all the secondary effects upon which Righi based the need and proof of his new theory, could be reproduced when there was no magnetic field at all. It was further shown that the "magnetic ray" differed only from the unmagnetised cone of rays, issuing from the hot-lime kathode, by bending towards or away from the pole of the test magnet instead of at right angles to it. This effect, evidently, would require no new theory since a stream of negatively charged particles moving in helices, will bend towards or away from the pole of an auxiliary magnet whether these particles are constituents of doublets or not. Other reasons were given to show that this was not only not necessary but that it was contrary to facts Righi has not abandoned the theory and he has, in two new articles, published additional experiments and a rather severe criticism of the above conclusions.

The present experiments are in answer to Righi's criticism. If the rays from the kathode can be reduced to a sufficiently fine pencil of light, this line of light should be straight if Righi is correct and it should be a spiral if the other view is the right one. Gouy has shown the spiral form of these rays by an indirect method, and More and Mauchly also succeeded at times in making it visible. The authors have now succeeded in controlling the effect so that it is readily obtained. The directions of rotation indicate that the particles composing the spiral stream are negative. Results obtained show that at constant voltage and pressure the relation between field-strength and the pitch of the spirals is a rectangular hyperbola. The diam. of the spirals was always roughly one-tenth of the pitch. Well-defined spirals were obtained with voltages as low as 200. Undoubtedly the final test of the two theories must rest with the electrical nature of the "magnetic rays." If they consist of a stream of doublets, then they must be electrically neutral, but if they are deflected kathode rays they must certainly be charged with negative electricity. This difference has not been satisfactorily tested. Righi states that he received them in a Faraday pail and found them to be electrically neutral. On the other hand, Thirkill, by the same method, found them to be charged negatively. Results now obtained show clearly that the magnetic ray is a stream of negatively charged particles. Experiments on the secondary column are also described by which the presence of a virtual anode is confirmed. A. E. G.

1117. *A New Method of measuring Alternating Currents and Electric Oscillations.* **I. Williams.** (Phys. Soc., Proc. 30. pp. 235–252; Disc., 252–253, Aug., 1918. Electrician, 81. pp. 253–255, July 19, 1918.)—The method consists of the application of the Crookes and Osborne Reynolds radiometers to the measurement of the r.m.s. values of electric currents. Two types of apparatus are described. In the first of these the heat generated by the passage of the current through a nichrome resistance causes the deflection of a light mica vane attached to the extremity of a suspended beam. In the second type the deflection of a fine fibre is employed. Tables and curves are given connecting the indications of the instruments with the current and with the degree of evacuation. AUTHOR.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1118. *Weston Normal Cell.* **J. Obata.** (Math. Phys. Soc., Tōkyō, Proc. 9. pp. 416–424, July, 1918.)—Gives the results of a series of measurements of the cell in terms of the international ohm and international ampere, the Richards form of silver voltameter being used. The mean value obtained is $1{\cdot}01826_6$ int. volts at 20° C. The following table summarises some of the results obtained since 1910 :—

Date.	Country.	Form of Voltameter.	Number of Deposits.	E.M.F. Int. Volts.	Diff. from Mean.
1910	Germany	Kohlrausch	40	$1{\cdot}01829_0$	$+2_0$
1911–1912	United States	Richards	156	26_7	$-0{\cdot}_3$
1911–1912	United States	Smith	55	27_4	$+0{\cdot}_4$
1912–1913	Holland	Smith	32	26	$-1{\cdot}_0$
1914	Russia	Smith	4	29_5	$+2{\cdot}_5$
1915–1916	Japan	Smith	40	26_9	$-0{\cdot}_1$
1918	Japan	Richards	61	26_6	$-0{\cdot}_4$

Weighted Mean..................... $1{\cdot}01827_0$

[Experiments made at the National Physical Laboratory in 1910, at the Bureau of Standards in 1910, and by an International Committee at Washington in 1910 gave results agreeing with the above mean within a few parts in 100,000.—F. E. S.] F. E. S.

1119. *Influence of Temperature on the Electrical Resistivity and Thermoelectric Potential of Solutes in Steels.* **E. D. Campbell.** (Am. Electrochem. Soc., Trans. 32. pp. 193–208 ; Disc., 209–214, 1917.)—Previous experimental investigations by the author on the electrical resistivity and thermoelectric properties of steels have led him to formulate a theory of the dependence of these properties on the concentration of the carbides or other solutes in solution. In the present paper data of the resistivities and thermoelectric properties of 8 steels with carbon contents varying from 0·018 to 1·18 %, after varying thermal treatment, and at various temperatures up to 100° C. are recorded, with the object of showing that temperature affects these electrical properties of the solvent and the solute differently. The chief conclusions drawn are :—(1) The temperature coefficient of the electrical resistivity due to carbides in solution is positive, but only about 1/4 that of pure iron. (2) The temperature coefficient of the resistivity due to silicides as well as that due to W and Ni in solution is small but negative. (3) The thermoelectric potential of a single solute in solution is dependent on chemical composition and concentration, and is a linear function of the temperature. (4) When two or more solutes are in solution at the same time, the thermoelectric potential due to these solutes is not a linear function of the temperature and not dependent upon the total molecular concentration. (5) The thermoelectric potential of solutes in metallic solution is analogous to the solution tension of electrolytes in aqueous solution. In the *discussion*, **W. D. Bancroft, C. G. Fink,** and **J. W. Richards** objected to the theory propounded in that the structure of the system is entirely ignored. L. L.

1120. *Formulæ for Mutual and Self-inductance.* **F. W. Grover.** (Bureau of Standards, Bull. 14. pp. 537–570 [Sci. Papers No. 320], 1918.)—This paper is supplementary to previous papers on the subject published by the Bureau of Standards, and brings the list of formulæ up to date. Butterworth's series formulæ for the calculation of the mutual inductance of two parallel coaxial circles are compared with those given by others, and it is shown that they diminish the labour of computation. Butterworth's formulæ for the mutual inductance of parallel eccentric circles are next considered, and various particular cases are given and numerical examples are worked out. The formulæ for a cylindrical current-sheet are given, and also Lyle's formula for the self-inductance of a circular coil of rectangular cross-section. Notes are given on the calculation of the self- and mutual inductance of linear conductors, and the inductance of shunts is also considered. In the Appendix are to be found tables of the values of the zonal harmonics which occur in some of the formulæ, and also tables for the constants in Lyle's formula. A. R.

1121. *Calibration of Condenser Transmitter; an Air-damped Vibrating System.* **I. B. Crandall.** (Phys. Rev. pp. 449–460, June, 1918. Paper read before the Am. Phys. Soc., Dec., 1917.)—The object of this paper was the completion of the mechanical theory of the condenser transmitter. The mechanism of the air-damping has been determined, and formulæ have been obtained from which practical calculations can be made. A complete theoretical calibration of a condenser transmitter has been given which is consistent with the experimental calibration, and which does not disturb the uniform frequency-sensitiveness characteristic of the instrument except at frequencies very near zero. The principles are here given for the design of air-damped systems of max. damping, and condenser transmitters having rigorously uniform sensitiveness over an extended range of frequencies including zero. [See Abs. 1162 (1917).] E. H. B.

ALTERNATING CURRENTS AND MAGNETISM.

1122. *A Property of Ferromagnetism.* **P. Weiss.** (Comptes Rendus, 167. pp. 74–76, July 8, 1918.)—Two sets of magnetisation curves are given for nickel: in the first, magnetisation is plotted against temperature for a range of temperature in the neighbourhood of the Curie point; in the second, the field is given as a function of the temperature for definite values of the specific magnetisation σ. This second series shows that a linear relation exists between the magnetisation and the field-strength when σ is constant. The linear relation is interrupted at a certain point, and the locus of these points separates the plan into two regions, each corresponding to a different state of matter. Defining the molecular field H_m by the equation: $A_m = -dU/d\sigma$, where U is the energy of the substance, it is deduced mathematically that H_m depends solely on σ. This result is also brought out by the curves. [See also Abs. 871 (1918).]
G. E. A.

1123. *Weiss Molecular Field in Ferromagnetic Substances.* **K. Honda.** (Tôhoku Univ., Sci. Reports, 7. pp. 53–58, July, 1918. Eighteenth Report of the Alloys Research Inst. Phys. Rev. 12. pp. 238–242, Sept., 1918.)—A criticism of the Weiss theory of the molecular field. The evidence in proof of the theory is: (1) The explanation of the magnetic properties of magnetite and pyrrhotine by means of the demagnetising field; (2) The existence of corresponding states in ferromagnetic substances; (3) The applicability of the relation $\chi\,(T - \theta) = \text{constant}$; (4) The change of the specific heat in the critical range of iron, nickel, and magnetite. The author and Okubo have argued that the first three of these cannot be considered as proof of the validity of the theory [see Abs. 1287 (1916)]; and in the present paper reasons are given to show that the last piece of evidence is inconsistent with the observed fact.
G. E. A.

RADIOGRAPHY AND ELECTRO-CHEMISTRY.

1124. *Arrangement for obtaining a Uni-directional High-tension Current from Three-phase Current.* **O. M. Corbino** and **G. C. Trabacchi.** (N. Cimento, 15. pp. 34–48, Jan.–Feb., 1918.)—The object is to obtain an arrangement which will remove some of the limitations which are inevitable with the induction coil as at present employed. This it proposes to do by a special grouping which enables a periodically interrupted 3-phase current to be used, and by arranging a "make" of the current at a suitable interval after each "break" so that the core is magnetised in the opposite sense to the preceding. The experiments described indicate that it is possible to make an apparatus of this type to suit the many different circumstances that are met with in practice. Various diagrams illustrating the grouping and connections are given.
A. E. G.

1125. *The Characteristic of a Coolidge Tube.* **F. Klingelfuss.** (Archives des Sciences, 46. pp. 49–50, July, 1918. Paper read before the Soc. Suisse de Physique.)—A table is given showing the results obtained as to initial and final hardness of the tube, with the corresponding currents. Results show that tubes with an incandescent kathode give a great variability in the hardness of the tube and the range of the X-ray spectrum obtainable, but that they do not replace qualitatively a number of suitably chosen self-lighting tubes of differing degrees of hardness. The tube also leaves much to be desired so far as clearness of the image is concerned.
A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1126. *Spectroscopic Estimation of Small Amounts of Lead in Copper.* **C. W. Hill** and **G. P. Luckey.** (Am. Electrochem. Soc., Trans. 32. pp. 335–340; Disc., 341–343, 1917. Met. and Chem. Eng. 17. pp. 659–660, Dec. 1, 1917. Am. Inst. Mining Eng., Bull. No. 142. pp. 1581–1592, Oct., 1918.)—For the rapid estimation of lead in factory samples of copper, a known weight of copper is placed in a slight cavity in a lower, positive, graphite electrode, and a fixed or rotating carbon is used as the upper, negative electrode. A grating spectroscope serves to observe the spectrum. The time required to cause the disappearance of the bright lead line, 405·8 $\mu\mu$, in the spectrum, or to cause its enfeeblement to a certain dimness, is measured with a stop-watch. With a carefully regulated arc, the times vary regularly with the amount of copper used and with its percentage of lead, for example, from 14 secs. with 0·2 gm. of copper containing 0·004 % of lead to 277 secs. with 1 gm. of copper containing 0·038 % of lead. The results are sufficiently reliable for practical use in the copper refinery.

In the *discussion*, it was stated by one of the authors that attempts to connect the intensity of the lead line with the percentage of lead in the sample were not successful. T. S. P.

1127. *Effect of Cold-work on the Divorce of Pearlite.* **J. H. Whiteley.** (Iron and Steel Inst., J. 97. pp. 353–364, 1918. Engineering, 105. pp. 562–564, May 17, 1918.)—In an earlier research [*ibid.* Carnegie Schol. Mem. 8, 1916] the author has shown that cold-work generally increases the apparent value of the carbon content of steel as determined by the Eggertz test. Contrary to expectation, however, the effect of the removal of the strain by annealing below 690° C. is further to increase the apparent carbon content. Microscopic examination has shown that the effect of such annealing is to cause divorce of the pearlite in such a way as to induce the cementite laminæ to assume the spheroidal form. This begins at about 500° C. and the rate of change increases with rise of temperature. In strained steel at 680° C. the change can be completed in 2 hours, while in unstrained steel the result is only effected after 4 days' heating. The condition obtained by straining and heating to 650° C. is similar to that obtained by quenching and tempering at the same temperature. F. C. A. H. L.

1128. *Iron, Carbon, and Phosphorus.* **J. E. Stead.** (Iron and Steel Inst., J. 97. pp. 389–412, 1918. Engineering, 105. pp. 573–577, May 24, 1918.)—This forms Part II ofthe author's previous paper [see Abs. 1480 (1915)]. The conclusions arrived at are summarised as follows:—

(1) It has been proved that the pearlite areas in medium-carbon phosphoretic steel castings, and the ferrite immediately enveloping these areas, contain much less P than the ferrite exterior to them.

(2) As carbon enters into phosphorised iron by cementation, the phosphide of iron diffuses out of the areas invaded by the carbon, and is concentrated in solid solution in the surrounding ferrite; this concentration increases as the carbon increases until the ferrite becomes saturated with the phosphide.

(3) The amount of carbon capable of passing into iron by cementation at any given temperature, short of the ternary eutectic formation point, depends upon the amount of P present and varies inversely with the amount.

(4) If the temperature of the cementation furnace exceeds the formation

point of the liquid ternary eutectic, the internal tension in the ferrite rich in P, due to the continued increasing external tension of the invading carbon at last becomes so great that the phosphide is forced out of solid solution in the very centre of the ferrite, forming a eutectic liquid.

(5) It is confirmed that graphite can carburise iron without the interposition of any gaseous vehicle, and that the carbon, in diffusing from graphite nuclei bedded in iron containing phosphide in solid solution, behaves in a similar way to carbon from CO: it concentrates the phosphide in the ferrite and eventually at 1200° to 1300° C. throws it out of the solid into the liquid solution, producing the ternary eutectic Fe–C–P, which appears in the globular form and as intercrystalline envelopes, and finally liquates out of the metal.

L. H. W.

1129. *Effect of Mass on Heat Treatment.* **E. F. Law.** (Iron and Steel Inst., J. 97. pp. 333–347; Disc., 348–352, 1918. Engineering, 105. pp. 647–650, June 7, 1918.)—The fact that the molecular changes occurring in steel depend, both as regards magnitude and the temperatures at which they occur, on the initial temperature of heating and the rate of cooling, introduces, in the heat treatment of large masses of steel, difficulties such as are not met with in treating small masses. In order to get some idea of the time taken to heat uniformly a large mass of steel in a furnace, and of the depth of effective hardening resulting from oil and water quenching, 18-in. cubes of a 0·34 % carbon steel were prepared. Heating and cooling curves were taken by means of 3 thermo-couples placed, one in the centre of the cube, one ½ in. deep in the centre of one surface, and the third exactly half-way between the other two. The noticeable feature about the heating curves is the rapidity with which heat travels to the centre until the occurrence of the *Ac* change, which causes a greater lag at the centre than elsewhere. With an initial furnace temperature of 900° C., 4¼ hours is required for the cube to attain uniformly the approximate temperature of the furnace. On cooling, the oil-quenched cube shows the *Ar* point at the centre but not at the half-way point. In the water-quenched cube the change is apparently completely suppressed. A peculiarity of the water-quenched cube is an acceleration in the rate of cooling in the interior between 200° and 250° C. Subsequent experiments on smaller cubes indicates that whatever the rate of cooling through the higher ranges of temperature (down to 300° C.), no appreciable hardening effect is obtained. Hardening is effective only when the rapid cooling is continued through the lower ranges of temperature. The phenomenon is, therefore, ascribed to the existence of a lower change-point in steel previously foreshadowed by Robin and others. Mechanical tests were made throughout the large cubes and microscopic examination was made. The paper concludes with a criticism of the amorphous cement theory of hardening and some interesting suggestions are offered.

F. C. A. H. L.

1130. *Iso-piestic Solutions.* **W. R. Bousfield.** (Faraday Soc., Trans. 13. pp. 401–410; Disc., 410–413, June, 1918. Chem. News, 116. pp. 312–315, Dec. 28, 1917.)—By iso-piestic solutions the author means solutions of equal vapour pressure, and the experiments were carried out with the object of correlating the various osmotic data with the number *h* of molecules of water per mole of solute, and to deduce the number *n* of molecules of water combined with a mole of solute. The method adopted consisted in placing the salts or solutions to be observed in separate open vessels in a common receptacle, which was evacuated to facilitate the exchange of vapour between the solutions in an aqueous atmosphere common to them all, maintained at a uniform temperature. The purpose of the main investigation was to determine the relative degrees of hydration of iso-piestic solutions of different salts. Thus it was found that for solutions of the following salts, after their solutions had stood in the same aqueous atmosphere for several days at a temperature of 18°, to arrive at final equilibrium, the values of h for solutions of KCl, NaCl, and LiCl were 12·41, 14·16, and 17·07 respectively. One important result of the investigation is to show that for a pure salt without water of crystallisation, there is, at a given temperature, a certain vapour pressure of water, below which the dry salt surrounded by aqueous vapour will not take up water, and will, if it is not dry, become dried. This pressure may be called the critical hydration pressure of the salt at the given temperature. If the vapour pressure of one of the solutions is known, the others can also be calculated in mm. of mercury. As standard, the vapour pressure of solutions of LiCl was taken. From relations previously established by the author it is possible also to calculate the hydration of the salts in solution. The data for saturated solutions of the three salts at 18° are—

	h.	$\delta p/p$.	a.	$h - n$.	n.
KCl	12·43	0·1336	0·540	11·54	0·89
NaCl	9·13	0·2072	0·486	7·18	1·95
LiCl	3·00	0·875	0·400	1·60	1·40

A. F.

1131. *The Thermal Properties of Sulphuric Acid and Oleum.* **A. W. Porter.** (Faraday Soc., Trans. 13. pp. 373–399 ; Disc., 399–400, June, 1918.) —Since existing determinations of the thermal properties of mixtures of sulphuric acid and water have been carried out only in the neighbourhood of atmospheric temperature, the author gives the results of two indirect methods, depending on thermodynamical relations, for obtaining the necessary data at other temperatures. For the heat set free at temperature t when 1 gm. of SO_3 is diluted with M gm. of water the author obtains the formula $h_t = 504{\cdot}2M/(M + 0{\cdot}2013) + 0{\cdot}714M\,(t - 15)/(M + 0{\cdot}062)$ and for the true or differential heat of dilution

$$D_t = 101{\cdot}5/[M + 0{\cdot}2013]^2 + 0{\cdot}0443\,(t - 15)/[M + 0{\cdot}062]^2.$$

The units employed are gm. and calories. The heat necessary to concentrate from any one strength of acid to any other is also calculated. Taking as standard an amount of dilute acid containing 1 gm. of SO_3 and M_1 gm. of water, the heat required to evaporate it at constant temperature till it only contains M_2 gm. of water is given by the formula—

$$\int_{M_2}^{M_1} L\,dM = \int_{M_2}^{M_1} L_{\text{water}}\,dM + \int_{M_2}^{M_1} D\,dM = L_{\text{water}}\,(M_1 - M_2) + [h]_{M_2}^{M_1}$$

The results calculated by these formulæ are given fully in tables and charts. Formulæ for the thermal properties of oleum have similarly been obtained and tabulated, in forms suitable for technical application to the processes of sulphuric acid and oleum manufacture. A. F.

1132. *Non-metallic Inclusions: their Constitution and Occurrence in Steel.* **A. McCance.** (Iron and Steel Inst., J. 97. pp. 239–286, 1918.)

1133. *Metallography of Aluminium.* **R. J. Anderson.** (Met. and Chem. Eng. 18. pp. 172–178, Feb. 15, 1918.)—Includes 18 reproduced photomicrographs.

1134. *Periodic System of the Elements.* **S. Meyer.** (Phys. Zeits. 19. pp. 178–179, May, 1918.)—The author gives two new ways of representing the periodic system of the elements. A. F.

1135. *Heats of Dilution and their Variations with Temperature.* **F. R Pratt.** (Frank. Inst., J. 185. pp. 663–695, May, 1918.)—By thermodynamic calculations the variation of the heat of dilution of a solution with change of temperature is equal to the rate at which the heat capacity of the solution changes with the concentration. Previous determinations of the heats of dilution have failed to support this relation in some cases. It was the object of this research to find out, if possible, whether this discrepancy is real or the result of experimental error. The result is that, in a general way, the theoretical formula seems to hold.

The original should be consulted for the numerous tables and curves.
L. H. W.

1136. *Potentials of Chloride Electrodes.* **A. A. Noyes** and **M. Chow.** (Am. Chem. Soc., J. 40. pp. 739–763, May, 1918.)—In this research the specific or normal potentials at 15, 25, and 35° of the electrodes $\left.\begin{matrix}\text{Bi}\\ \text{BiOCl}\end{matrix}\right\}, \begin{matrix}\text{H}^+\\ \text{Cl}^-\end{matrix}$ and $\left.\begin{matrix}\text{Cu}\\ \text{CuCl}\end{matrix}\right\}, \text{Cl}^-$ are derived from measurements of cells formed by combining these electrodes separately with a hydrogen electrode (H_2, H^+) and with each other.

From the change of the electrode potentials with the temperature the corresponding heat effects at 25° are computed. L. H. W.

1137. *Relation between Specific Inductive Capacity of an Electrolyte and Electric Potential of a Metal Placed in it.* **D. L. Ulrey.** (Phys. Rev. 12. pp. 47–58, July, 1918.)—The p.d. between electrodes of the same kind in a two-solution cell has been measured for a number of different percentage mixtures of two liquids for four different cases, and in each, after disturbing influences were removed, is shown to be strictly proportional to the difference in the specific inductive capacities of the two solutions.

In the two cases investigated with copper electrodes, one with platinum and six with calomel electrodes, the direction of the e.m.f. of the cell is in accordance with the theory that the loss of ions from an electrode is dependent upon the specific inductive capacity of the electrolyte rather than upon the concentration of those ions in the electrolyte and a solution tension of the electrode. L. H. W.